CONTRACT SERIAL NO. 99131-01-SQ
CONTRACT REQUISITION NO. 23440-9-9131
CONTRACTOR: LAKEFIELD RESEARCH

UNIT COLUMN FLOTATION

Of Highland Valley Copper
and
Falconbridge Strathcona Ores

Volume 1 - Final Report

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology (CANMET), Energy Mines and Resources, Canada

DSS File Number	:	003SQ.23440-9 9131
DSS Contract Number	:	23440-9-9131/-01-SQ
CANMET Scientific Authority	:	Kwang S. Moon, PhD.

52 pp

LAKEFIELD RESEARCH
A Division of Falconbridge Limited
December 18th, 1990

MICROMEDIA

UNIT COLUMN FLOTATION

A LAKEFIELD RESEARCH / CANMET

SHARED COST PROGRAM

Volume 1

Project No. L.R. 3897

NOTE:

This report refers to the samples as received.

The practice of this Company in issuing reports of this nature is to require the recipient not to publish the report or any part thereof without the written consent of Lakefield Research.

LAKEFIELD RESEARCH
A Division of Falconbridge Limited
December 18th, 1990

ABSTRACT

Unit flotation refers to the practice of recovering valuable minerals from grinding circu.. classification sands using large capacity single flotation cells.

The main advantage of unit flotation is the recovery of values immediately upon liberation in the grinding circuit, thus significantly reducing the adverse effects of overgrinding. Unit cell concentrates are normally produced at or near final product grades, and are typically coarser than main circuit products. The problems associated with unit cell flotation include persistent sanding and accelerated wear. The purpose of the present study was to demonstrate that unit flotation could be conducted in a column flotation cell, thus gaining the inherent advantages of column flotation - improved selectivity with no loss in recovery - and eliminating the sanding and wear problems associated with mechanically agitated unit cell flotation.

The application of column flotation technology to coarse "unit" flotation was investigated in a series of pilot scale tests designed to simulate two existing milling operations - Highland Valley Copper and Falconbridge Strathcona.

In the Highland Valley Copper pilot plant circuit, an ore grading 0.4% Cu was upgraded in conventional flotation to 36.7% Cu at a recovery of 67.3%. The 80% passing size (P80) of the final concentrate was 96 μm. Incorporation of unit column flotation in the grinding circuit improved the grade by 4 units to 40.4% Cu with a 1 unit loss in recovery. At comparable recoveries, it is expected that a 3% improvement in grade would be possible. The P80 of the final concentrate, at 108 μm, was coarser by 12 μm when the unit column was incorporated in the circuit.

In the Falconbridge Strathcona pilot plant circuit, a nickel / copper ore grading 1.4% Ni as pentlandite was upgraded in a bulk Ni / Cu flotation circuit to about 3.8% Ni at a recovery of about 90%. Incorporation of unit column flotation resulted in a marginal improvement in grade with no significant change in recovery.

TABLE OF CONTENTS

Page No.

TITLE.......... 1
ABSTRACT.......... 2
TABLE OF CONTENTS.......... 3
1. Introduction.......... 4
2. Summary.......... 6

2.1 Phase One - Highland Valley Copper.......... 6
2.1.1 Production Sample.......... 6
2.1.2 Sample Preparation.......... 6
2.1.3 Pilot Plant Circuit.......... 6
2.1.4 Circuit Startup.......... 9
2.1.5 Baseline Tests.......... 10
2.1.6 Unit Column Flotation.......... 12
2.1.7 Examination of Unit Column Performance.......... 13
2.1.7.1 Effect of Froth Depth.......... 13
2.1.7.2 Effect of Froth Washing.......... 14
2.1.7.3 Effect of Gas Holdup.......... 14
2.1.7.4 Effect of Frother Dosage.......... 16
2.1.8 Size-by-Size Performance Analysis.......... 17
2.1.9 Overall Performance Comparison.......... 21
2.1.9.1 Overall Copper Grade.......... 22
2.1.9.2 Overall Copper Recovery.......... 23
2.1.9.3 Overall Product Size.......... 24
2.1.10 Phase One Conclusions.......... 25

2.2 Phase 2 - Falconbridge Strathcona.......... 26
2.2.1 Production Sample.......... 26
2.2.2 Sample Preparation.......... 26
2.2.3 Pilot Plant Circuit.......... 26
2.2.4 Circuit Startup.......... 28
2.2.5 Baseline Tests.......... 28
2.2.6 Unit Column Flotation Tests.......... 29
2.2.7 Examination of Unit Column Performance.......... 29
2.2.7.1 Effect of Froth Depth.......... 29
2.2.7.2 Effect of Froth Washing.......... 29
2.2.7.3 Effect of Gas Holdup.......... 30
2.2.8 Size-by-Size Performance Analysis.......... 31
2.2.9 Overall Performance Comparison.......... 36
2.2.10 Phase Two Conclusion.......... 40
3. General Summaries.......... 41

Testwork Details for PHASE ONE can be found in VOLUME II
Testwork Details for PHASE TWO can be found in VOLUME III

1. Introduction

The term **Unit Flotation** applies to a process for recovering economic minerals at the coarsest possible size and at final concentrate grade, usually from a grinding circuit process stream - primary rod mill discharge, secondary ball mill discharge or classifier sands. Other terms applied to this process include **Unit-Cell Flotation, Classification Flotation, Coarse Flotation and Flash Flotation.** This last is the trade name for a proprietary process marketed by Outokumpu Oy of Finland. Unit Flotation is commonly conducted in one or, at most two, large capacity flotation cells - hence the name.

It is well understood that liberation of values from gangue can occur at relatively coarse particle sizes, and that the flotation kinetics of such coarsely liberated particles can be very fast. It is economically attractive to recover coarse values for a number of reasons, including:

1 - recovery of values at the coarsest possible size reduces fines losses when a mineral tends to slime readily, thereby reducing grinding costs and increasing the capacity of the grinding circuit, as well as all down-stream process stages.

2 - inclusion of a coarser fraction with final concentrate improves the efficiency of settling and filtration, and reduces the cost of concentrate drying and transportation.

3 - removal of coarse free values can, in some cases, minimize fluctuations in mill feed grades, thus resulting in inherently more stable downstream operation with attendant improvements in grade and recovery.

Unit flotation cells are installed in grinding circuits at the head end of mills and must therefore be of sufficient capacity to treat 100% or more (up to 250%) of the mill feed, and to treat it at a relatively coarse size. For conventional, mechanically agitated flotation cells, the problems associated with this rigorous service are persistent sanding, which is alleviated by incorporating special designs for sand relief which can cause short-circuiting, and by imparting high mixing energy - and accelerated wear, which is a direct result of the solution to the sanding problem.

In column flotation, the problems associated with sanding are reduced or eliminated by the simple expedient of removing all non-floating solids from the bottom of the cell in the normal course of operation. Further, having no agitator, the problems associated with high wear due to mechanical agitation do not exist. Particle-bubble contact is achieved in a quiescent collection zone in which solids, moving downward under the force of gravity, encounter a rising swarm of bubbles. By its nature, column flotation reduces short-circuiting. Particles have no opportunity to short-circuit directly to tails, but must travel the entire length of the collection zone in plug flow fashion. Similarly, particles dropping back from the froth zone have available to them the entire residence time for re-collection.

The objective of this project was to demonstrate the inherent advantages of unit column flotation by conducting parallel pilot scale tests to compare a representative conventional flotation circuit operating without unit column flotation to the same circuit incorporating a unit column flotation stage in the grinding circuit.

The program was conducted in two phases, with each phase devoted to a complete evaluation of a single ore type. In phase one, a copper porphyry ore provided by Highland Valley Copper was evaluated. The second phase focussed on a complex nickel-copper sulphide provided by the Strathcona Mill of Falconbridge.

LAKEFIELD RESEARCH

James [illegible] Furey, P. Eng.
Senior Engineer

Marion O'Connor
for Bert J. Huls, P.Eng., Ph.D.
Manager - Technology

2. Summary

2.1 Phase One - Highland Valley Copper

Highland Valley Copper agreed to provide a 15 tonne sample of coarse mill feed, delivered to Lakefield Research, at no charge.

The Highland Valley Copper porphyry deposit is located in south-central British Columbia. The ore is predominantly bornite, with a typical head grade of 0.47% copper. The ore also contains economic amounts of molybdenum, but the focus of the present study was on the copper.

Highland Valley Copper mills about 110,000 tonnes per day (40,000,000 tonnes per year) in five main production lines, and produces copper concentrate grading about 40% Cu at a recovery of about 85%.

2.1.1 Production Sample

A 15 tonne sample was collected from one of two main conveyors moving ore from the in-pit crushing plant to the mill complex. Mill feed was momentarily diverted at a conveyor transfer point midway between the pit and the mill. About 100 tonnes of muck was moved out first to ensure that a fresh sample would be available. A 15 tonne sample was then conveyed to a highway haulage truck for shipment to Ontario.

2.1.2 Sample Preparation

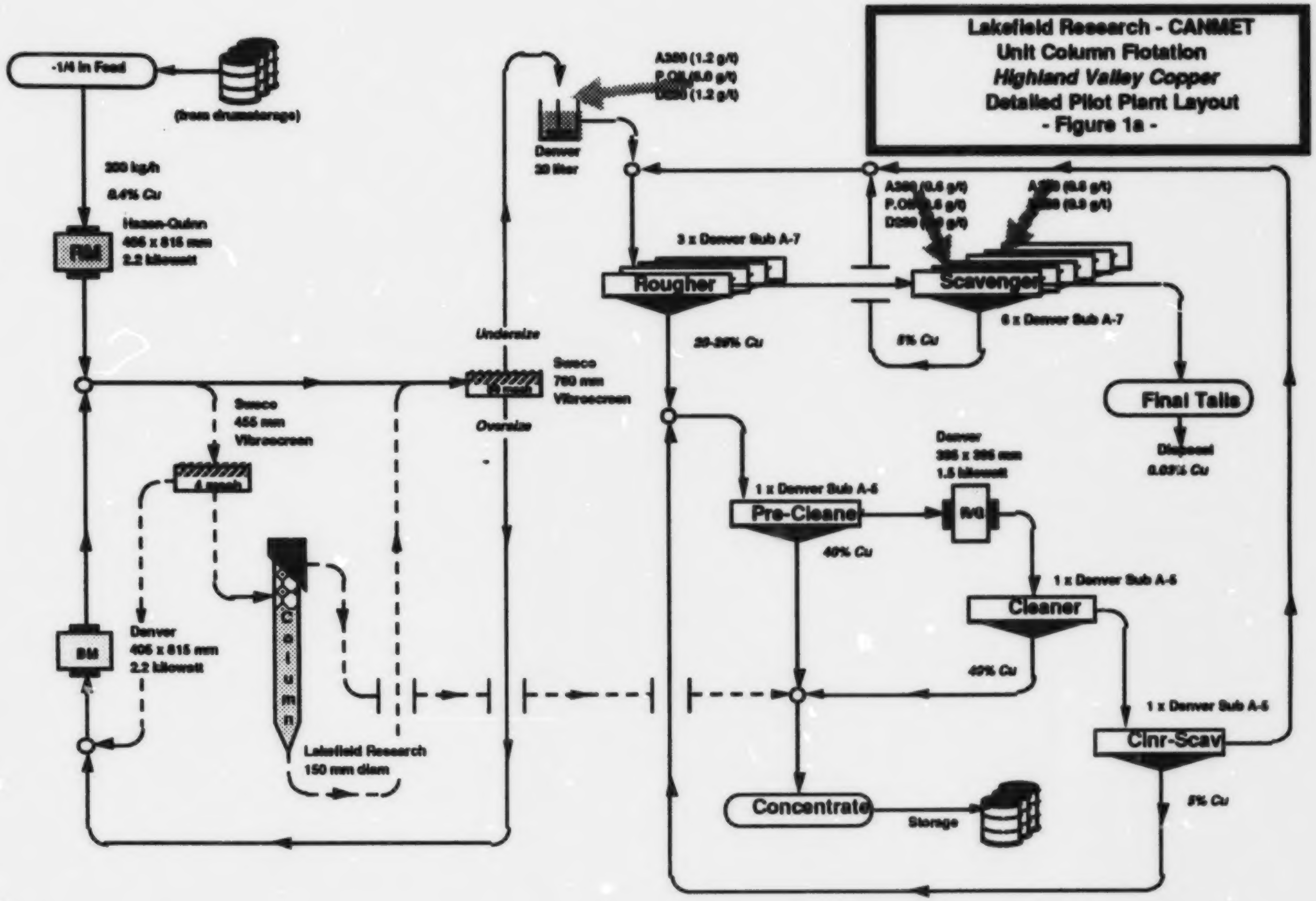
The 15 tonne sample received at Lakefield Research consisted of -25 cm coarse muck. The sample was unloaded onto a clean concrete pad for short term storage. The sample was then prepared by crushing in an open circuit jaw crusher followed by a Hazemag Impact Crusher operating in closed circuit with a Kason Vibroscreen mounting a 6 mm (1/4 inch) sieve deck. The screen undersize was automatically sampled to recover a 1/50th mass fraction as a reference sample, with the remainder being stored in clean 200 liter drums.

2.1.3 Pilot Plant Circuit

The objective of the program, as mentioned previously, was to duplicate, in pilot scale, an appropriate portion of an existing plant circuit. At the recommendation of Highland Valley Copper staff, the pilot plant circuit was designed to simulate the "D and E Line" circuit at Highland Valley Copper. Only the copper rougher and the cleaner portions of the circuit were simulated in pilot scale. Since the objective of the program was to evaluate recovery of copper from the grinding circuit, it was decided that inclusion of a molybdenum separation circuit would not materially add to knowledge of unit column flotation of copper, and would unnecessarily complicate the circuit.

It should also be pointed out that, although the D and E Line circuit incorporates column flotation in the cleaning stages, it was decided to use conventional mechanical cells for pilot scale cleaning. Again, this decision was taken in the interest of simplicity of operation. An exact simulation of the Highland Valley Copper circuit was not judged to be necessary, since the unit column would be evaluated by comparing the performance of the circuit with and without the unit column cell, and the establishment of a reliable "base line" was of greater importance.

The pilot plant circuit is depicted graphically in Figure 1a, and a detailed equipment list is given in Table 1a. The pilot plant feed rate was set at 200 kg/h in order to best accommodate the largest column cell then available at Lakefield Research (150 mm diameter, 65 liter) and to optimize utilization of the available 15 tonne sample.



Lakefield Research - CANMET
Unit Column Flotation
Highland Valley Copper
Detailed Pilot Plant Layout
- Figure 1a -

LAKEFIELD RESEARCH

Table 1a - Phase One Equipment List

Rod Mill	Hazen-Quinn 405 mm x 815 mm 2.2 kilowatt
Ball Mill	Denver 405 mm x 815 mm 2.2 kilowatt
Primary Screen	Sweco Vibroscreen 760 mm diameter
Unit Column	Lakefield Research 150 mm diameter 3.65 meter high 65 liter
Primary Conditioner	Denver 20 liter
Rougher Flotation	3 x Denver Sub A-7 28 liter per cell 0.37 kW per cell
Scavenger Flotation	6 x Denver Sub A-7 28 liter per cell 0.37 kW per cell
Pre-Cleaner Flotation	1 x Denver Sub A-5 7.7 liter per cell 0.19 kW per cell
Regrind Ball Mill	Denver 305 mm x 305 mm 1.5 kilowatt
Cleaner Flotation	1 x Denver Sub A-5 7.7 liter per cell 0.19 kW per cell
Cleaner Scavenger	1 x Denver Sub A-5 7.7 liter per cell 0.19 kW per cell

2.1.4 Circuit Startup

The pilot plant circuit was started without the unit column. The objective of the first few test shifts was to certify that the gross operating characteristics of the various components of the circuit were operating satisfactorily. Such things as pump selection, pump rotation, pipe line diameters and pipe line routing were checked for proper operation. Since pumping requirements in the grinding circuit were the most severe, only the grinding circuit was started on the first shift. Samples of screen undersize (flotation feed) were collected and submitted for size analysis. It was determined that the primary screen sieve aperture, at 80 mesh, was too fine and produced a flotation feed of 83.2% -100 mesh. By the third shift, the screen had been coarsened first to 60 mesh and finally to 24 mesh, at which time the flotation feed size was about 55% -100 mesh, which was on target.

2.1.5 Baseline Tests

During the startup shifts, numerous changes were made to accommodate the requirements of pumping very coarse material at very high densities. The improvements were effective, and the overall circuit was generally acceptable in terms of gross operating characteristics. The circuit was then operated for a number of shifts in order to establish an acceptable baseline metallurgy.

The baseline metallurgy would then be used as a basis of comparison for performance of the circuit with and without unit column flotation. It should be noted that it was not likely that an exact match of the Highland Valley Copper circuit would be easily achieved since a decision had been made early in the program to use mechanical cleaners rather than column cleaners, in the interest of simplicity of operation. It should also be noted that an exact match was not judged to be of critical importance, since the objective was to compare performance with and without unit column flotation. During the baseline tests a number of reagent changes were made in order to come as close as possible to Highland Valley Copper metallurgy. Upon completion of test PP-9, it was observed that the concentrate grade was slightly below target at about 39% Cu, and the recovery was significantly below target at about 65%. The low grade was probably a result of using mechanical rather than column cleaners, and that the low recovery was at least partly attributable to the low head grade, as well as possible deficiencies in the mechanical cleaners. It was decided that further testing would not significantly improve these base line results, and that the project should proceed to a comparison of overall performance with the unit column in the grinding circuit.

The following table highlights the major changes made to the reagent schedule in the baseline tests, as well as the changes in circuit feed grade.

Table 2 - Summary of Baseline Reagents and Head Grades

Test	g/t A350	g/t DF250	g/t Pine Oil	%Cu
PP-1	4.11	5.66	13.1	0.37
PP-2	4.82	4.95	15.2	0.36
PP-3	4.71	4.10	13.9	0.40
PP-4	5.90	3.48	15.0	0.35
PP-5	6.13	3.38	15.6	0.42
PP-6	6.42	3.36	15.8	0.34
PP-7	6.45	3.68	11.9	0.35
PP-8	9.16	3.34	11.9	0.35
PP-9	9.66	3.33	11.5	0.33
Average	6.37	3.92	13.8	0.36

Note that the dosage of potassium amyl xanthate collector (A350) was more than doubled in order to improve recovery, while the dosage of Dowfroth 250 frother (DF250) was reduced by 40% in order to reduce mass recovery and improve grade.

Note also that the average feed grade of 0.36% Cu was about 25% lower than typical Highland Valley Copper feed. It is significant that the 15 tonne sample sent to Lakefield Research represented about 11 seconds of High Valley Copper mill feed. The lower feed grade, therefore, may well have been within acceptable limits of variation.

The following table summarizes the metallurgical results of base line testing.

Table 3 - Summary of Baseline Metallurgy

Test	Feed %Cu	Conc Mass%	Conc %Cu	Cu Recovery	Tails %Cu
PP-1	0.37	0.94	29.2	74.7	0.09
PP-2	0.36	1.05	23.2	67.2	0.12
PP-3	0.40	0.62	32.9	50.6	0.20
PP-4	0.35	0.66	37.6	70.5	0.10 *
PP-5	0.42	0.77	36.6	66.4	0.14
PP-6	0.34	0.61	34.3	61.5	0.13
PP-7	0.35	0.57	39.3	63.2	0.13 *
PP-8	0.35	0.64	37.7	70.1	0.10 *
PP-9	0.33	0.55	38.9	64.5	0.12 *
Average	0.36	0.71	34.4	65.4	0.13
Avg. of Best 4(*)	0.35	0.61	38.4	67.1	0.11

Even with the lower head grade, it was not possible to achieve a tailings assay lower than 0.10. Overall, the concentrate grade was 2 units low, and the recovery was about 17 units low.

2.1.6 Unit Column Flotation Tests

In spite of the poor baseline tests, it was decided to incorporate the unit column cell in the grinding circuit and to evaluate its potential to improve on the baseline metallurgy. The unit column was therefore inserted into the grinding circuit treating the screen feed. The process stream of choice in an operating plant would be classifier sands (typically cyclone underflow). In the present circuit, however, the need to classify -4 mesh material would require a cyclone of significantly higher capacity than the 200 kg/h circuit could provide, and classification had therefore to be conducted using a screen. Since screen undersize was at a density much too high (+80% solids) to be pumped, it was necessary to install the unit column on the screen feed line. This service in fact required the unit column to treat a higher than normal mass throughput, and therefore represented a stringent test of the process.

The column used was a Lakefield Research 150 mm diameter glass unit shortened to 365 cm (from 485 cm). This unit, in normal flotation feed service, would process 100 to 125 kg/h of solids. In the present program, the unit column was required to process up to 1,200 kg/h of solids. It will be appreciated that operation under these severe conditions presented several unique problems. Following a number of modifications to the material handling system, and through careful operation and close monitoring, it was shown however that a unit column could indeed be operated under these severe conditions.

Aside from the problems arising out of the coarse grind, high density and high mass flow rates, perhaps the most interesting problem centered on the very low feed grade. In the grinding circuit, the quantity of copper mineral that was liberated sufficiently to be collected as a flotation concentrate was very low, and the column typically recovered a mass fraction of less than 0.5%. As a result, the froth was extremely sparse, and it proved very difficult to maintain a froth column. The solution, developed at Lakefield Research, was to use a froth crowder. To achieve crowding and force the sparse froth to exit the column, the wash water distribution cylinder was lowered into the froth, to a depth of about 6 cm. The outside diameter of the wash water distribution cylinder was 112.7 mm and, when inserted into the 150 mm diameter unit column, allowed an annular opening of 77 cm^2, thus resulting in a 56% reduction in froth area. This constriction increased the rise velocity of the froth sufficiently to sustain concentrate production. It was observed that when the crowder was removed, froth production became sporadic and occasionally stopped altogether. Although froth crowding is not, of itself, a new technique, its application to unit column flotation may be novel.

2.1.7 Examination of Unit Column Performance

The operation of column flotation cells, no matter the service, requires that several key variables be measured and controlled. Unlike mechanical cells, column cells can operate with froth depths of 2 meters or more, can utilize a wide range of aeration rates, and feature a froth washing capability. These three parameters - froth depth, gas rate and wash rate - are examined in more detail.

2.1.7.1 Effect of Froth Depth

As was mentioned earlier, the low feed grades resulted in a very sparse froth, with mass recoveries as low as 0.12%, and generally less than 0.30%. Under these conditions, with very little mineral available to armour the bubbles, it was not possible to achieve froth depths greater than about 30 cm. In one test (PP-21) the froth depth was reduced to 14 cm with no significant effect. In fact, contrary to expectations, the grade remained high and recovery was not improved. In general, it was found that the range of froth depths normally examined in a column flotation test program were not available in the present program, and froth depth was not judged to be a critical control variable.

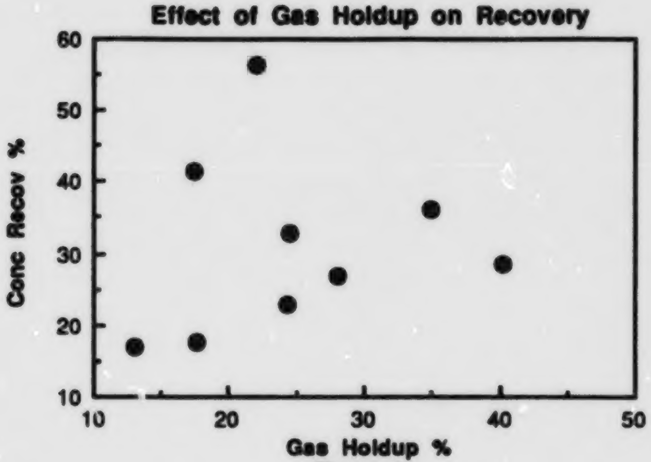
2.1.7.2 Effect of Froth Washing

The function of froth washing in column flotation is to replace feed pulp water with fresh water, thereby virtually eliminating gangue entrainment. A secondary, but important, function of the froth wash water is to stabilize the froth bed by creating a packed bed of bubbles, thereby permitting relatively tall froth columns to be established and maintained. In the present study, the stabilizing influence of wash water proved to be indispensable - without wash water, the column was incapable of producing a froth. In one test (PP-19) the wash water was reduced to the absolute minimum, which had the effect of reducing both the grade and recovery. The loss in grade was undoubtedly a result of increased gangue entrainment, and the loss in recovery appears to have resulted from destabilization of the froth bed. At the other end of the froth washing scale, it was not possible to significantly increase the wash water rate without causing complete collapse of the fragile froth bed. Given that a certain minimum amount of wash water was necessary (about 0.10 cm/s) and that the upper limit was restricted by the fragile nature of the froth, it was concluded that froth wash water was not a critical control variable.

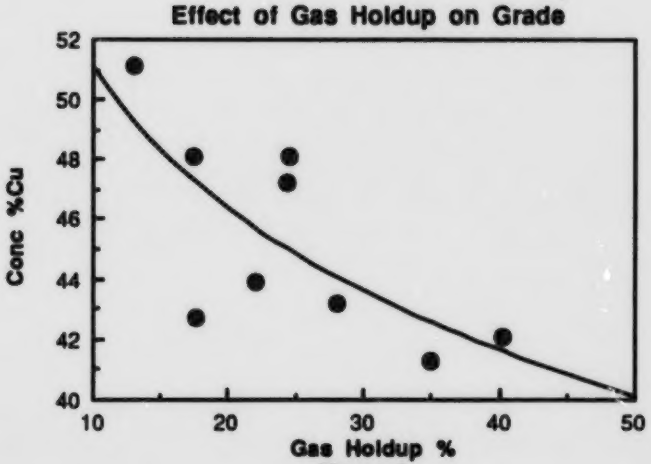
2.1.7.3. Effect of Gas Holdup

Gas holdup in a flotation column is defined as the proportion of operating volume of slurry which is comprised of gas (air). In the present study, the gas holdup was varied from a low of 13% to a high of 40%. At the low end, the 13% gas holdup was found to be the minimum that would produce a sustainable froth. The upper end of the range was substantially higher than gas rates normally used in more conventional applications of column flotation. While the lowest gas rate, as expected, produced the highest grade at the lowest recovery, the highest gas rates did not significantly improve recovery. It should be noted that the highest gas holdup occurred when the grinding circuit was operated with a very high circulating load ratio. In this test (PP-22), the unit column was processing 1,200 kg/h of solids, at a density of 56% solids and a nominal residence time of only 1.6 minutes. Clearly, the high downward velocity of slurry in the column severely reduced the net rise rate of bubbles, thus producing an artificially high holdup of gas within the column. This extreme operating condition was not judged to be beneficial in any way. Gas holdup, however, proved to be perhaps the only control variable with the ability to significantly affect performance of the unit column.

The relationships between gas holdup and both recovery and grade are shown in Figures 2 and 3 as follows:



- Figure 2 -

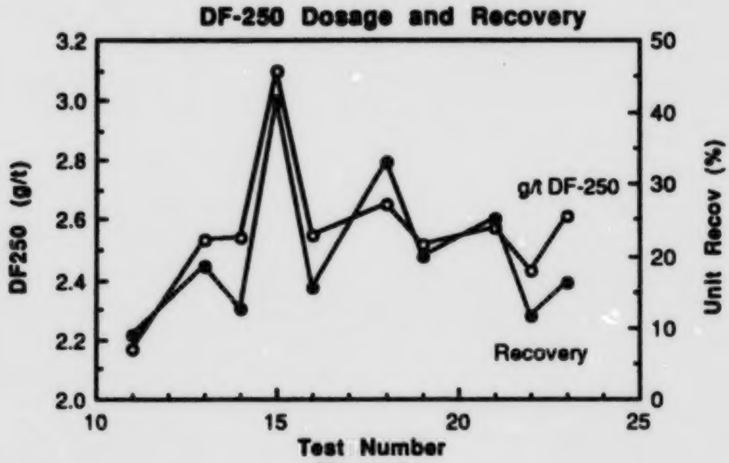


- Figure 3 -

These graphs show that there is no clear effect of gas holdup on recovery in the range tested, but there is a clear relationship between gas holdup and grade. As expected, increased gas holdup resulted in a lower grade. It is significant, however, that at no time did the grade drop below 40% Cu.

2.1.7.4 Effect of Frother Dosage

An examination of the effects of all reagents showed that the only clear relationship existed between Dowfroth 250 frother and copper recovery, as shown in Figure 4.

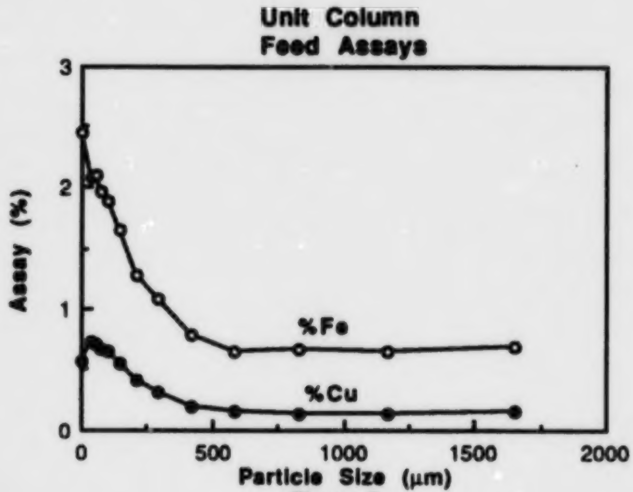


- Figure 4 -

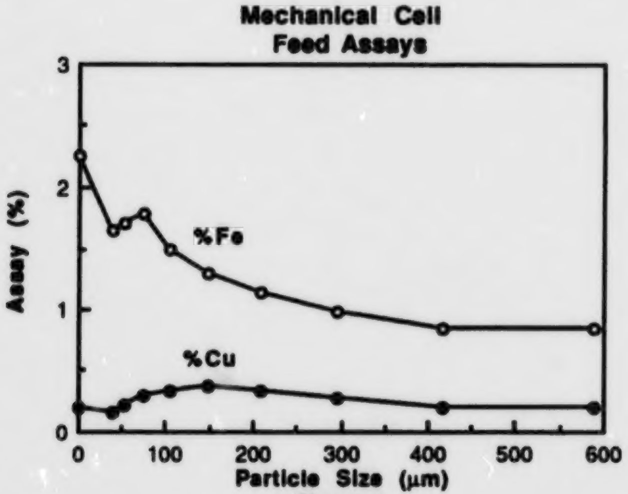
This graph clearly shows a direct relationship between DF-250 dosage and copper recovery.

2.1.8 Size-by-Size Performance Analysis

In tests PP-22 and PP-23, assay size distribution data were collected on a number of key products. The results for test PP-23 are examined in more detail.

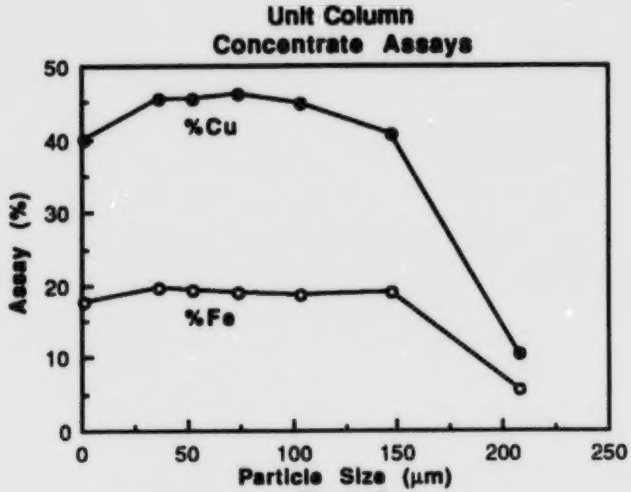


- Figure 5 -

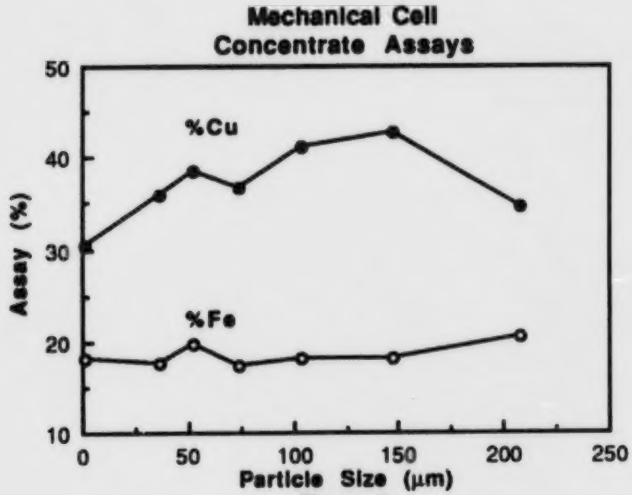


- Figure 6 -

These graphs show that the finer size fractions in the feed to both the unit column and mechanical flotation circuits contained higher grades of copper.



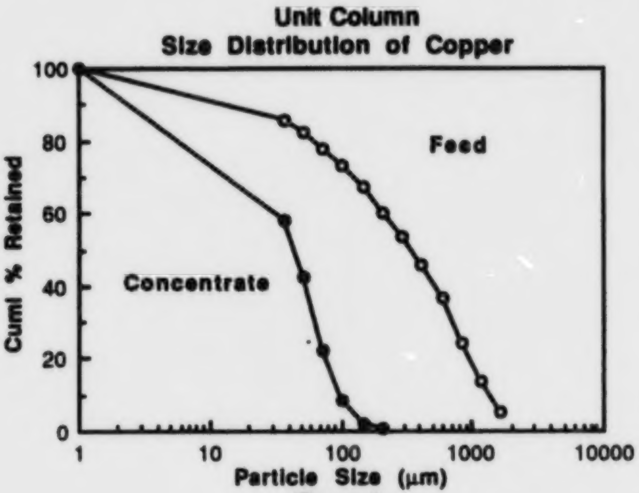
- Figure 7 -



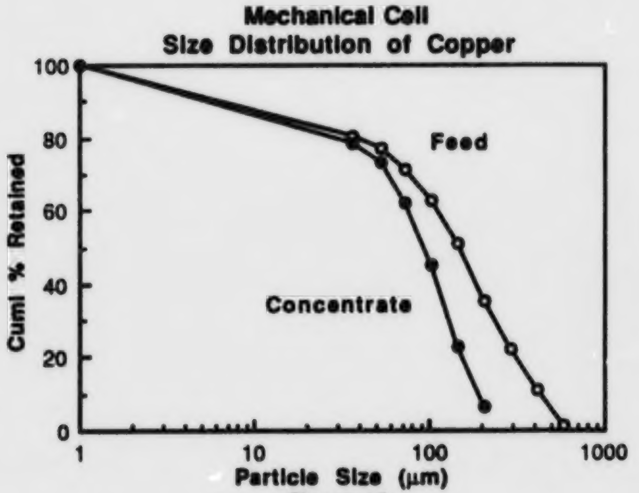
- Figure 8 -

These graphs show that the concentrate assays were higher in the finer fractions for the unit column. This effect may have resulted from the fact that liberated copper recovered in the unit column was no longer available for recovery in the mechanical circuit.

In the following two graphs, it can be seen that the unit column recovered a much finer concentrate, relative to feed size, than did the mechanical cell.



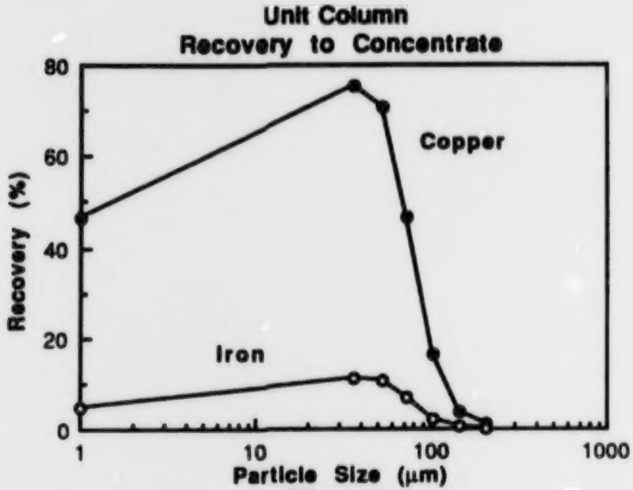
- Figure 9 -



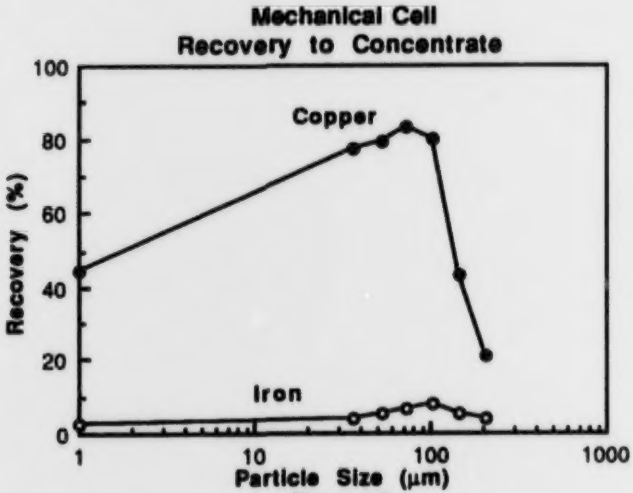
- Figure 10 -

In fact, the concentrate recovered by the unit column was finer in absolute terms than the mechanical circuit concentrate, in spite of the much coarser feed to the unit column, and also in spite of the fact that mechanical circuit included a regrind stage.

In the following two graphs, showing the size-by-size recovery of copper in the respective concentrates, it can be seen that, in the unit column, copper recovery peaked at about 40 μm, while in the mechanical circuit, copper recovery was highest at 80 μm.



- Figure 11 -

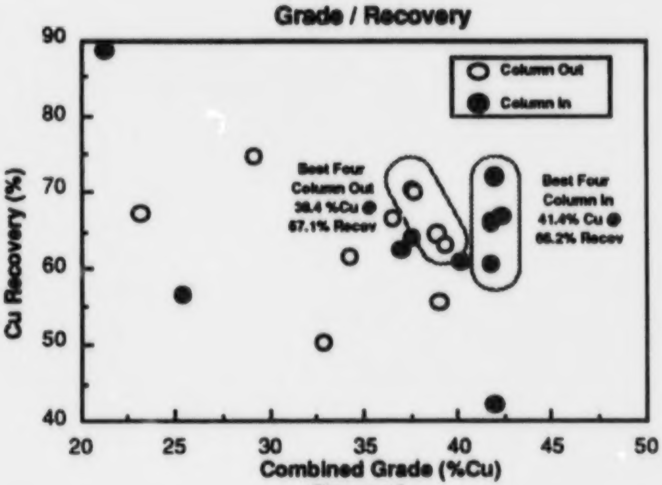


- Figure 12 -

2.1.9 Overall Performance Comparison

It was shown in the previous pages that it was indeed possible to conduct unit flotation in a column cell. What remains is to examine the performance of the entire circuit. In order for unit column flotation to be judged a success, it must demonstrate the ability to improve the overall grade and/or recovery of copper. Production of a coarser final product would also be considered beneficial.

Figure 13 illustrates the grade/recovery relationship, for the combined final concentrate, with the unit column both in and out of the circuit. The *best four* tests for each condition are outlined for comparison.

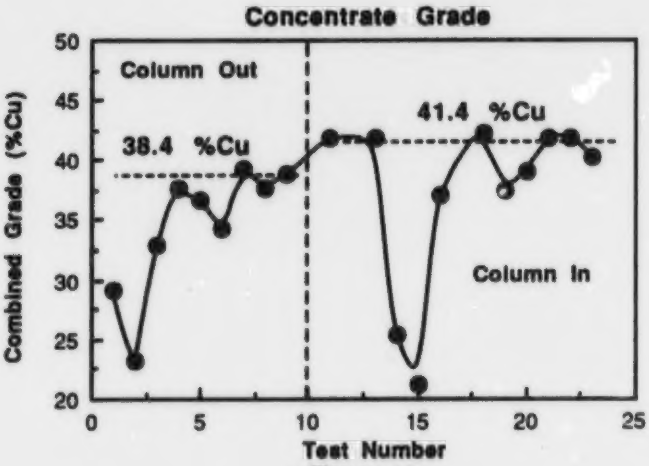


- Figure 13 -

This graph clearly shows that the circuit containing the unit column flotation stage performed better in terms of grade and nearly as well in terms of recovery. The position of the best four column in tests, to the right of the best four column out tests, shows that, in the context of overall performance - grade plus recovery - the unit column circuit was superior.

2.1.9.1 Overall Copper Grade

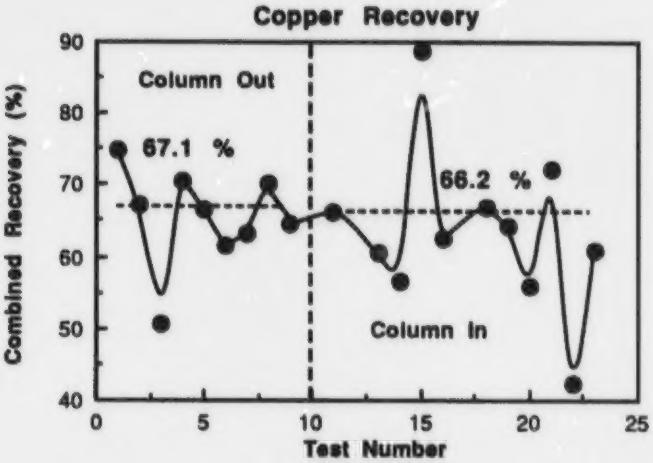
It has been shown that the unit column achieved consistently higher concentrate grades than the mechanical circuit without unit column flotation. When the unit column was incorporated into the circuit, the grade of the mechanical cell concentrate dropped even lower due to prior removal of liberated copper by the unit column. In the following graph however, it can be seen that, when the high grade unit column concentrate was blended with the lower grade mechanical concentrate, the combined final concentrate was, in fact, almost 3 units higher, based on the average of the *best four* tests. Incorporation of the unit column cell improved the grade from 38.4% Cu to 41.4% Cu.



- Figure 14 -

2.1.9.2 Overall Copper Recovery

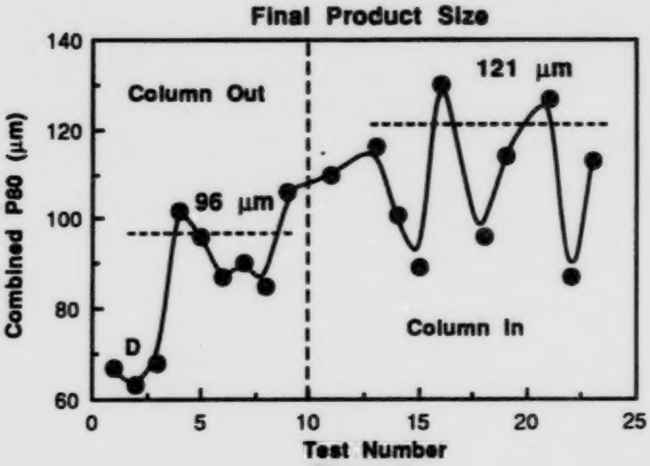
The recovery of liberated copper in the unit column resulted in a feed to the mechanical circuit that was depleted of the most readily flotable mineral. This resulted in a slight loss in recovery, from 67.1% to 66.2%, again based on the average of the *best four* tests. It is felt, however, that a portion of the substantial grade improvement might be sacrificed to improve the overall recovery. Figure 15 indicates that copper recovery was quite variable and that, with further optimization, an overall improvement in both grade and recovery might be realized.



- Figure 15 -

2.1.9.3 Overall Product Size

It has been shown that the unit column unexpectedly produced a finer concentrate than the mechanical circuit, in spite of the very coarse feed to the unit column. Removal of this relatively fine copper in the unit column cell, however, permitted, or resulted in, production of a significantly coarser mechanical circuit concentrate. In Figure 16, it can be seen that this combination yielded a combined final concentrate that was coarser by 25 μm K_{80}.



- Figure 16 -

2.1.10 Phase One Conclusions

The overall objectives of this study were to determine if unit flotation could be conducted in a column cell, and to examine the potential benefits of unit column flotation. In Phase One of the program, much of the development work necessary to make unit column flotation a viable process was successfully completed, and it was shown that unit flotation could indeed be conducted in a column cell.

The specific objectives relating to Highland Valley Copper ore were to improve the grade, recovery and coarseness of the final product. It was shown that:

1 - grade was improved from 38.4% Cu to 41.4% Cu
2 - a recovery loss from 67.1% to 66.2% was incurred
3 - At comparable recoveries, it is expected that a 3% improvement in grade would be possible.
4 - The 80% passing size of the final product was increased from 96 µm to 121 µm

2.2 Phase Two - Falconbridge Strathcona

The second phase of this study was, in most respects, identical to the first phase. The ore source was different, and the mechanical flotation portion of the flowsheet therefore required some modifications. In addition, the tests with the unit column were interspersed with the "no column" tests, in order to observe any changes which might take place in the ore.

2.2.1 Production Sample

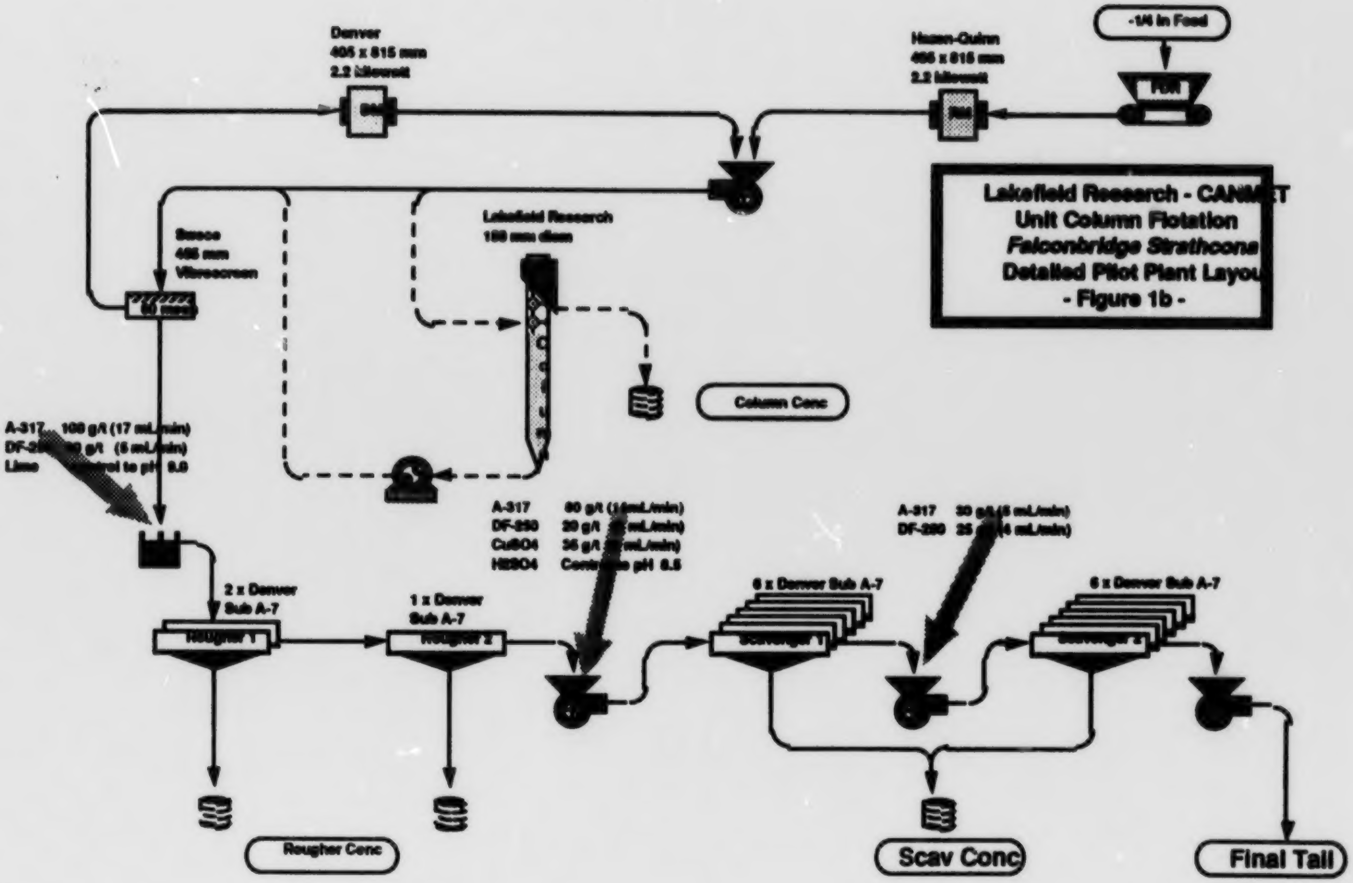
The ore for Phase Two was supplied by Falconbridge from the Strathcona Mill. The details of sample collection were not directly observed, but it was confirmed that the 15 tonne sample consisted of a representative sample of run-of-mine ore. This nickel-copper ore contained, on average, about 1.4% Ni as pentlandite, and 0.6% Cu as chalcopyrite. The ore also contained a high proportion of Fe as pyrrhotite. As a result of the high pyrrhotite content, the ore was subject to oxidation. For this reason, as mentioned previously, tests with and without the unit column were randomly interspersed.

2.2.2. Sample Preparation

At the start of Phase Two, a quantity of ore sufficient for five or six shift tests was crushed to -6 mm, as in Phase One. The remainder of the ore was reserved in un-crushed state, in order to minimize the effects of oxidation. As a result of commitments for pilot plant facilities at Lakefield Research, the study was held up for about two months in July and August. On re-starting the project in late August, it was decided to crush all remaining ore and to process the ore at the rate of two or three operating shifts per day for one week.

2.2.3 Pilot Plant Circuit

The flowsheet for Phase Two, shown in Figure 1b, included only roughing (in two stages) and scavenging, with no circulating streams in the mechanical flotation circuit. Although the actual Strathcona circuit is much more complex, it was decided that the needs of the present study would best be served by focussing on a simplified circuit and the performance of the unit column. The equipment list is shown in Table 1b.



Lakefield Research - CANMET
Unit Column Flotation
Falconbridge Strathcona
Detailed Pilot Plant Layou
- Figure 1b -

Table 1b - Phase Two Equipment List

Rod Mill	Hazen-Quinn 405 mm x 815 mm 2.2 kilowatt
Ball Mill	Denver 405 mm x 815 mm 2.2 kilowatt
Primary Screen	Sweco Vibroscreen 760 mm diameter
Unit Column	Lakefield Research 150 mm diameter 3.65 meter high 65 liter
Primary Conditioner	Denver 20 liter
Primary Rougher	2 x Denver Sub A-7 28 liter per cell 0.37 kW per cell
Secondary Rougher	1 x Denver Sub A-7 28 liter per cell 0.37 kW per cell
Scavenger Flotation	12 x Denver Sub A-7 28 liter per cell 0.37 kW per cell

2.2.4 Circuit Startup

Many of the problems associated with operating a pilot plant circuit at the relatively low feed rate of 200 kg/h and at the extremely coarse size of -4 mesh had already been worked out in the first phase of this study. As a result, the start-up for Phase Two was uneventful.

2.2.5 Baseline Tests

Several adjustments were made to reagent levels in the first few tests. The unit column was started early in the program (third test) in order that the reagents necessary to operate the column could be established. In subsequent tests, when it was desired to operate without the unit column, the column was removed from the circuit by the simple expedient of reducing gas flow to the unit column to a level just sufficient to prevent plugging of the gas sparger. Physically, the unit column remained in the circuit, with pulp still being pumped through it, and with all unit column reagent additions in place. This technique provided a better comparison between tests with and without the unit column.

Although in tests PP-25 to PP-30 the circuit was stabilized and reasonable results had been achieved, it was decided that the two month hiatus would have significantly altered the characteristics of the ore, and that the final eleven tests, conducted over a one week period, would provide the fairest comparison.

During these tests, the circuit was operated without the unit column for two tests, PP-34 and PP-37. In these two tests, the nickel grade and recovery in the primary rougher was higher than in tests which included the unit column. The average nickel grades and recoveries in the primary rougher for tests with and without unit column flotation are shown in Table 4. Note the decrease in rougher recovery due to depletion by the unit column.

Table 4 - Primary Rougher Performance

	Mass Recov. (Wt.%)	Grades		Recoveries		Size P80 µm
		(% Ni)	(% Pn)	(Ni)	(Pn)	
Column Out	12.7	6.35	16.4	64.2	67.5	119
Column In	9.4	5.06	12.8	35.6	36.8	139
Column + Rghr	14.5	5.74	14.6	61.7	63.9	122

This table shows that, in normal configuration (no unit column), the primary rougher recovered about 64% of the nickel at a grade of about 6.4% nickel. With the unit column in, the combined column plus rougher grade was about 10% lower. Recoveries of nickel and pentlandite were about 5% lower, but the combined concentrate was slightly coarser.

2.2.6 Unit Column Flotation Tests

The performance of the unit column in treating the higher grade Strathcona ore was physically more similar to "normal" column flotation, with a reasonable degree of froth loading and a consistent froth production rate. The froth had none of the characteristics of the "sparse" froth in the previous phase. In terms of grade and recovery of nickel, the unit column performed well, producing a higher grade concentrate at recoveries of about 30%.

2.2.7 Examination of Unit Column Performance

Although in this phase the unit column had a more substantial froth, it still proved very difficult to apply significant variations to the normal control variables such as level, wash water and gas rate.

2.2.7.1 Effect of Froth Depth

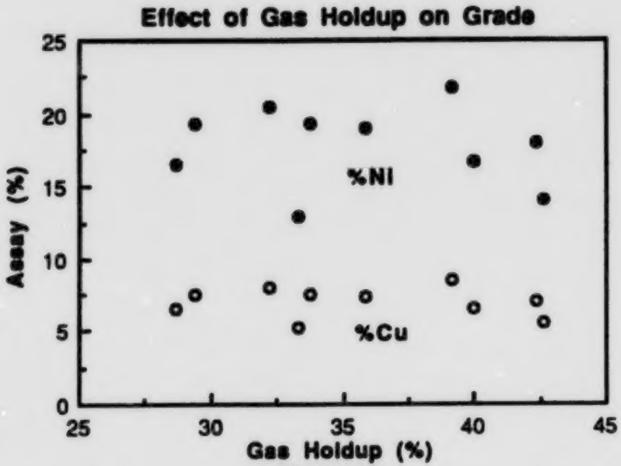
The froth depth was varied from a low of 25 cm to a high of 50 cm but there was no clear relationship between froth depth and either grade or recovery.

2.2.7.2 Effect of Froth Washing

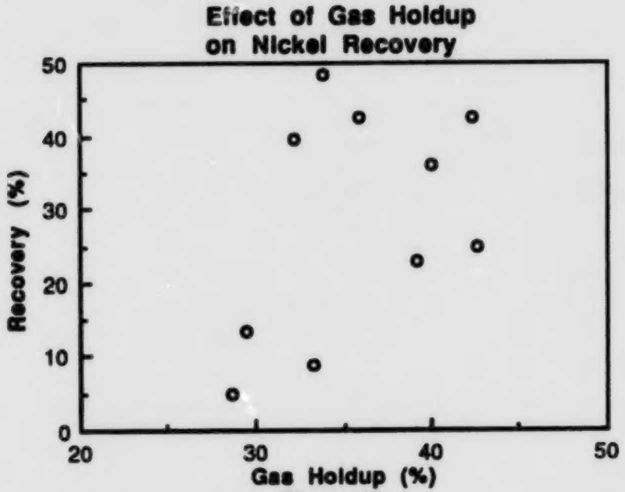
Several attempts were made to vary the wash water rate. Reductions in wash water rate caused the froth to become very unstable due to loss of the "packed bed" condition. Attempts to increase the wash water rate caused collapse of the froth. Finally, in each test, it proved necessary to return to a "medium" wash rate of 0.13 cm/s prior to sampling the circuit.

2.2.7.3 Effect of Gas Holdup

As in Phase One, gas holdup proved to be the only control variable that could be varied over any significant range. Figure 17 shows that variations in gas holdup from a low of about 27% to a high of more than 40% had little effect on the grade of Ni or Cu in the concentrate. Figure 18 illustrates a general trend toward increasing nickel recovery with increasing gas rate, but again the relationship is not clear.



- Figure 17 -

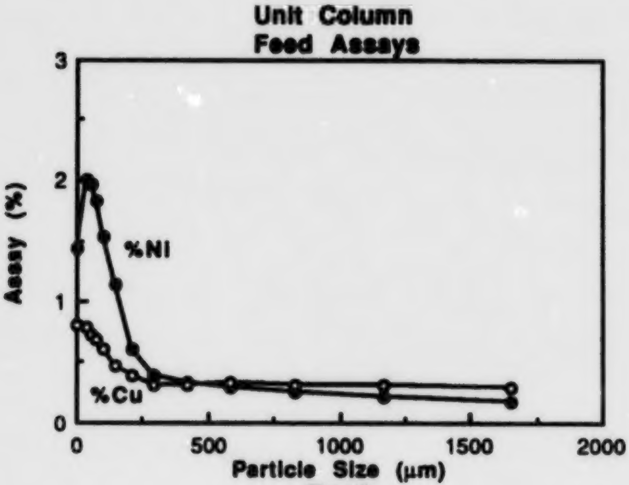


- Figure 18 -

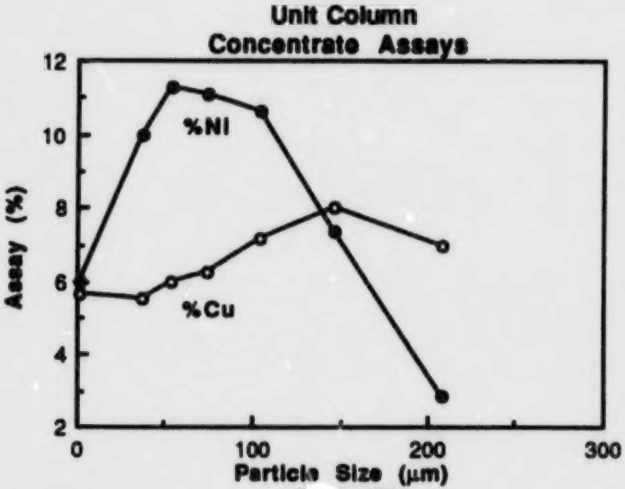
2.2.8 Size-by-Size Performance Analysis

In tests PP-36 (Column In) and PP-37 (Column Out) several key products were analyzed to determine the size-by-size behavior of the key minerals.

In Figures 19 and 20 it can be seen that Ni and Cu assays in the feed were highest in the fractions finer than 100 µm, and that, as a result, the concentrate also showed higher grades in the finer fractions.

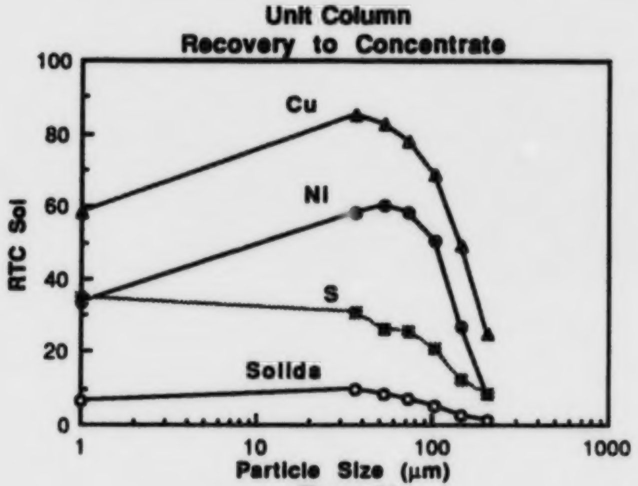


- Fig 19 -



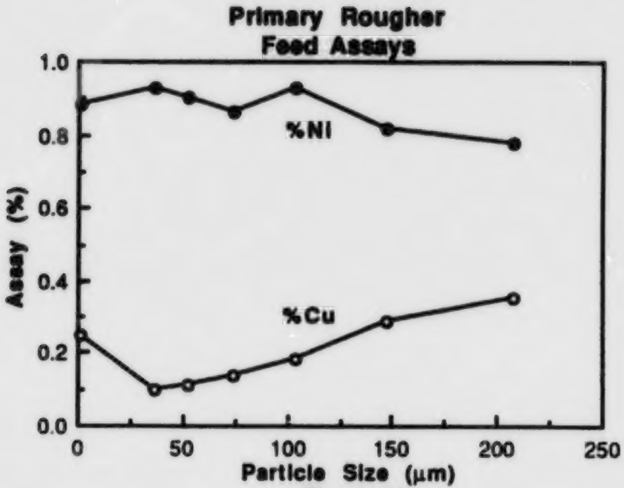
- Figure 20 -

Figure 21 shows that recovery of Cu and Ni was also at a maximum in the finer sizes, with copper recovery peaking at about 30 μm and nickel recovery peaking at about 50 μm.



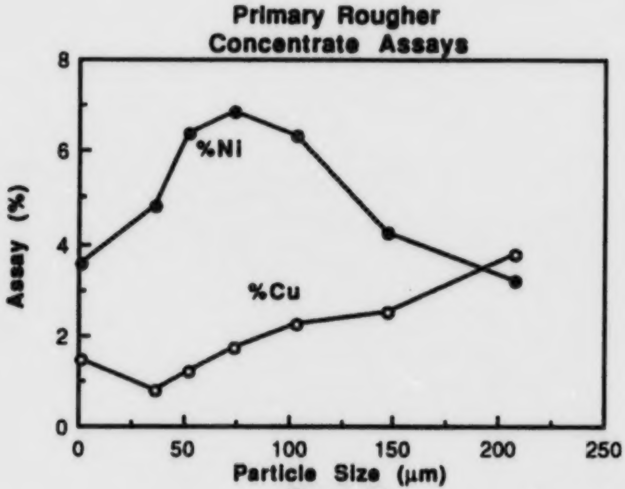
- Figure 21 -

In contrast, the feed to the mechanical portion of the circuit, as shown in Figure 22 on the following page, showed no preferential distribution of assays relative to particle size.



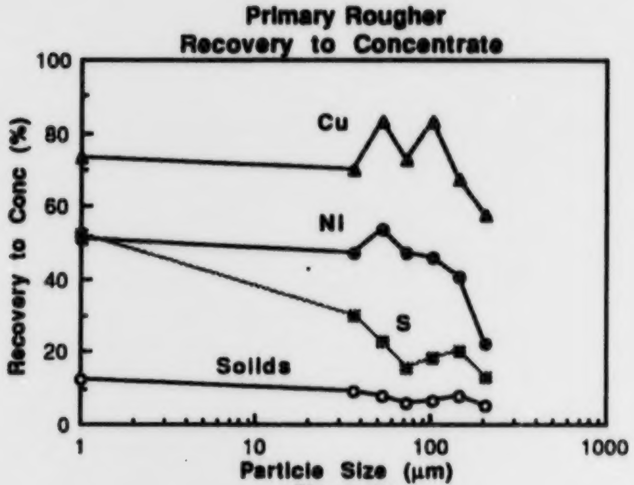
- Figure 22 -

In spite of this, the mechanical circuit concentrate showed improved nickel grade in the 50 to 100 μm size fraction, as shown in Figure 23.



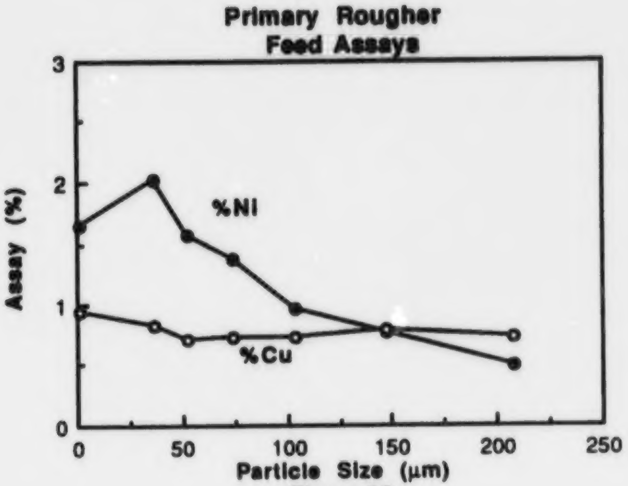
- Figure 23 -

Recovery to concentrate, as shown in Figure 24, was best in size fractions finer than 100 μm.

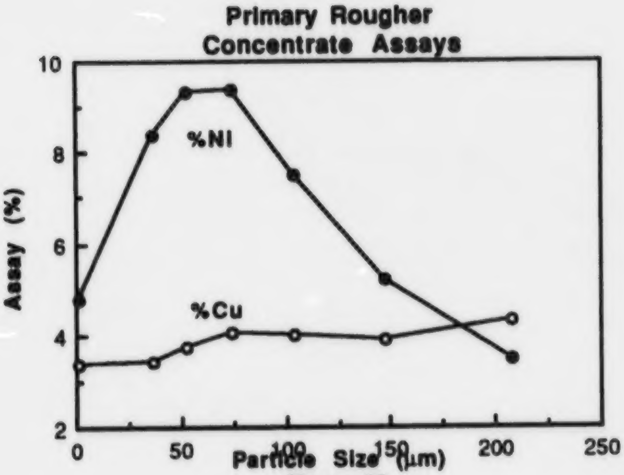


- Figure 24 -

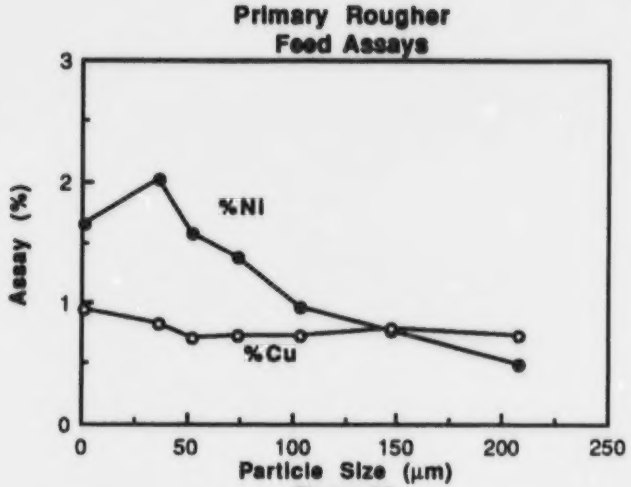
The fact that fine liberated values were effectively removed by the unit column can be seen by examining Figure 25 on the following page, which clearly shows that in test PP-37, with no unit column flotation, the feed to the mechanical circuit had higher assays in the finer fractions (compare with Figure 21). Figure 26 shows a much stronger assay peak for nickel in the finer sizes.



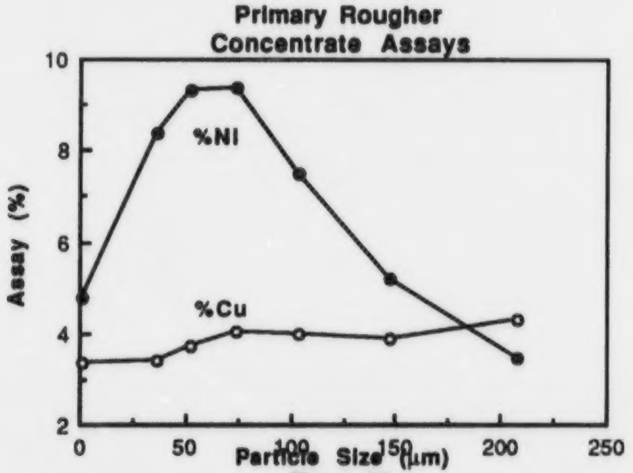
- Figure 25 -



- Figure 26 -


Primary Rougher Feed Assays

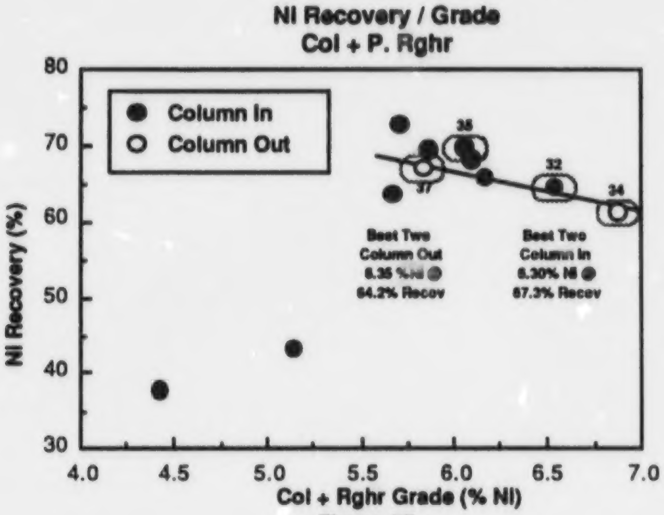
- Figure 25 -


Primary Rougher Concentrate Assays

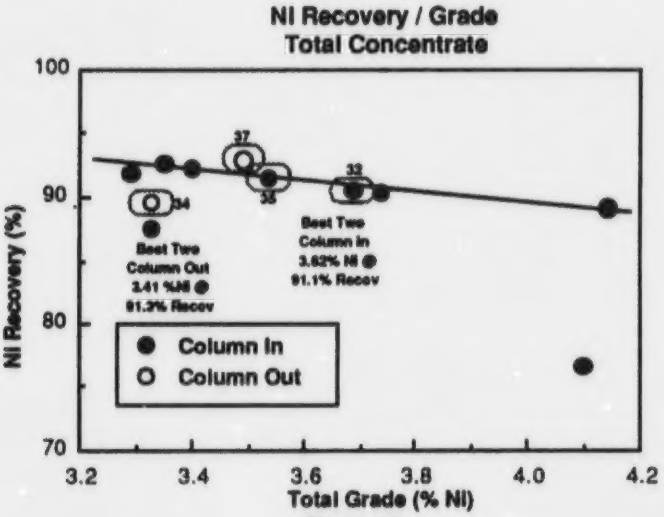
- Figure 26 -

2.2.9 Overall Performance Comparison

The ability of the unit column to improve performance of the overall Strathcona circuit must be viewed in the context of the total combined concentrate, including primary and secondary roughing plus scavenging, plus unit column flotation where applicable. It is also appropriate, however, to examine the performance of the unit column circuit in comparison to the primary rougher alone. Figures 27 and 28 below illustrate the grade/recovery curves for the primary rougher circuit and for the entire rougher-plus-scavenger circuit, each with the unit column in and out of the circuit.



- Figure 27 -



- Figure 28 -

From the grade/recovery data shown in Figure 29, tests PP-32 and PP-35 were selected as the best two *column in* tests to compare to the two *column out* tests, PP-34 and PP-37. These tests have been highlighted in Figure 29, and the same four tests are highlighted in Figure 30, to indicate the performance of the circuit as a whole. It can be seen that the data lie on a trend, and that the tests incorporating the unit column were not significantly better or worse than the tests with on unit column.

Table 5 shows the performance of the primary rougher portion of the circuit in terms of nickel grade and pentlandite recovery for the best two tests of each circuit. Table 6 shows the overall performance of the entire circuit, again for the best two tests of each circuit.

Table 5 - Summary of Unit Column and Primary Rougher

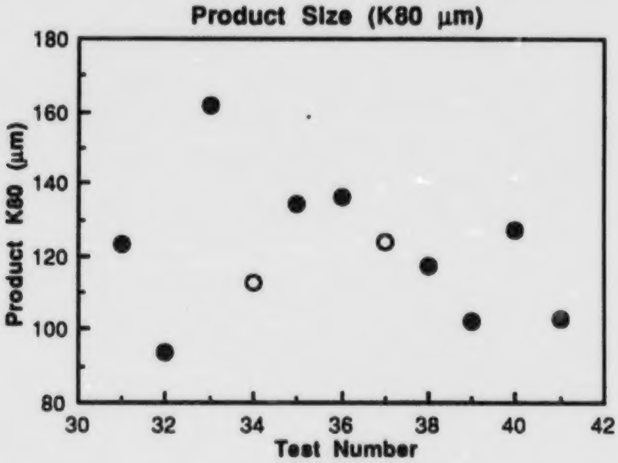
	Unit Column					Rghr + Unit Col				
	Mass	Grade		Recovery		Mass	Grade		Recovery	
	Wt.%	% Ni	% Pn	Ni	Pn	Wt.%	% Ni	% Pn	Ni	Pn
Column Out	-	-	-	-	-	12.7	6.35	16.4	64.2	67.5
Column In	7.9	7.18	18.5	42.5	44.9	14.1	6.30	16.2	67.3	70.6

Table 6 - Summary of Combined Concentrates

	Mass	Grade		Recovery	
	Wt.%	% Ni	% Pn	Ni	Pn
Column Out	33.3	3.41	8.31	91.3	93.2
Column In	33.2	3.62	8.79	91.1	90.6

Table 5 shows that the unit column produced higher grades than the primary rougher, but at lower recoveries. The combination of the unit column plus the primary rougher yielded similar grades with a slight improvement in recovery. From Table 6, however, it can be seen that inclusion of the unit column, in terms of overall circuit performance, had no significant effect on grades or Ni recovery, but resulted in a 3 unit loss in pentlandite recovery.

In terms of product size, the unit column produced a finer product, despite the much coarser feed. This phenomenon also occurred in the Phase One testing of Highland Valley Copper ore, and may, in fact, be a characteristic of unit column flotation. Figure 31, which shows the particle size produced in the primary rougher circuit - with and without the unit column - indicates that the removal of fine liberated values in the unit column resulted in the production of an overall coarser primary rougher concentrate. This effect also duplicates results observed in the Phase One testing.



- Figure 31 -

2.2.10 Phase Two Conclusions

As in Phase One, it was seen that column flotation in service as coarse unit flotation in a grinding circuit operates in a much narrower regime of control. Both wash water rate and froth depth were found to be effective only within a relatively close range of variation. In this test series, attempts made to vary the wash water rate resulted in froth collapse both at low rates - due to failure of the packed bubble bed - and at high rates - due to physical destruction of the relatively fragile froth.

The ability to vary the froth depth was not as severely limited as the ability to vary the wash water rate, but froth depth was found to be a relatively ineffective control parameter within the allowable range.

Gas rate, once again, was found to be the most useful control variable. In fact, it was found that gas holdups of 27% to 40% could be sustained. Within this range, concentrate grade was relatively unaffected, but a general trend towards increasing recovery with increasing gas rate was observed.

In general, incorporation of unit column flotation in the Strathcona circuit simulation resulted in a marginal increase in overall final concentrate grade with no significant change in recovery. Based on the test results, there is no metallurgical justification for unit column flotation in the Strathcona mill. The incorporation of unit column did, however, result in production of a coarser primary rougher concentrate, which may have benefits in product dewatering. The fact that the unit column was able to recover +40% of the pentlandite from the grinding circuit may have implications in regard to grinding capacity and may also be worthy of consideration for expanding mill throughput.

General Summaries - Phase One and Phase Two

Mill Feed Summary **Rod Mill Summary**

Test	Date	Mill Feed					Rod	Screen	Feed	Disch.	Rod Mill Discharge				Net	Work
	Month -Day	Wet kg/h	Dry kg/h	Moist %	Shift kg	Total tonnes	Charge kg	Size mesh	K80 µm	K80 µm	Density g/L	Density % Sol	% + 48 m	% - 100 m	Power kWh/t	Index metric
PP-24	05-24	193.8	190.0	2.0	484	0.5	160	60	3,325	861	1,660	56	46.5	40.2	2.93	17.5
PP-25	05-28	205.3	204.0	0.6	513	1.0	160	60	4,529	714	1,690	58	44.5	40.5	2.54	11.3
PP-26	05-30	197.3	194.4	1.5	1,036	2.0	160	60	3,221	738	1,600	53	47.4	37.3	2.96	15.4
PP-27	06-04	208.8	207.6	0.6	574	2.6	160	60	3,206	714	1,600	54	41.9	42.8	2.54	12.9
PP-28	06-16	199.3	195.0	2.2	548	3.2	160	60	3,680	572	1,670	57	40.7	42.0	3.67	14.5
PP-29	06-17	192.8	192.1	0.4	1,157	4.3	160	60	4,143	472	1,692	57	34.7	45.6	3.22	10.5
PP-30	06-18	195.8	193.0	1.4	1,224	5.5	160	60	4,140	546	1,702	59	39.5	42.9	3.21	11.8
PP-31	08-27	196.4	194.5	1.0	1,031	6.6	160	60	3,840	584	1,473	46	41.8	40.7	2.76	10.9
PP-32	08-27	199.9	196.6	1.7	1,399	8.0	160	60	4,233	619	1,575	52	42.4	41.3	2.94	11.8
PP-33	08-28	195.2	193.6	0.8	765	8.7	160	60	4,040	584	1,560	52	40.3	42.5	3.08	12.0
PP-34	08-28	199.1	196.6	1.3	996	9.7	160	60	4,420	537	1,638	55	37.3	44.1	3.00	10.7
PP-35	08-28	202.9	200.8	1.0	507	10.2	160	60	4,700	642	1,680	57	42.1	42.3	3.20	12.9
PP-36	08-29	193.3	191.1	1.1	837	11.1	160	60	3,932	629	1,698	58	41.0	42.1	3.36	14.1
PP-37	08-29	199.1	197.0	1.1	995	12.1	160	60	4,486	802	1,680	57	47.9	38.2	3.14	15.4
PP-38	08-29	193.3	190.5	1.4	837	12.9	160	60	4,577	759	1,650	56	46.9	37.9	3.19	14.8
PP-39	08-30	194.5	192.6	1.0	860	13.8	160	60	3,983	553	1,710	59	40.0	42.7	3.26	12.2
PP-40	08-30	195.4	192.7	1.4	864	14.6	160	60	4,401	516	1,690	58	38.6	43.2	3.22	11.1
PP-41	08-30	201.7	199.0	1.3	892	15.5	160	60	4,681	759	1,737	61	47.1	38.2	3.22	14.9
Avg		**198.0**	**195.6**	**1.2**	--	--	--	--	**4,085**	**645**	**1,650**	**56**	**42.3**	**41.4**	**3.1**	**13.0**
Max		208.8	207.6	2.2	--	--	--	--	4,700	861	1,737	61	47.9	45.6	3.7	17.5
Min		192.8	190.0	0.4	--	--	--	--	3,206	472	1,473	46	34.7	37.3	2.5	10.5
%S.D.		2.3%	2.4%	39%	--	--	--	--	11.8%	17.1%	4.0%	6.2%	8.9%	5.5%	9.0%	15.5%

Ball Mill Summary

Test	Ball Charge kg	Feed Rate kg/h	Feed K80 µm	Final K80 µm	Ball Mill Discharge Density g/L	Ball Mill Discharge Density % Sol	Ball Mill Discharge % + 48 m	Ball Mill Discharge % - 100 m	Circ Load %	Net Power kWh/t	Work Index metric
PP-24	100	889.4	861	165	1,660	56	74.1	13.2	468	--	--
PP-25	100	1,254	714	151	2,053	73	74.9	12.8	615	--	--
PP-26	100	940.7	738	169	--	--	68.4	14.1	484	--	--
PP-27	100	1,640	714	148	1,627	55	76.2	8.5	790	--	--
PP-28	100	162.0	572	145	1,730	60	9.5	66.4	83	3.32	8.0
PP-29	100	407.2	472	153	1,844	64	52.7	20.0	212	1.44	4.1
PP-30	100	283.0	546	140	1,778	62	50.9	20.1	147	1.95	4.7
PP-31	100	1,329	584	153	1,678	57	76.4	5.9	683	0.61	1.5
PP-32	100	446.4	619	155	1,975	70	76.8	4.4	227	1.60	4.0
PP-33	100	767.8	584	181	1,590	53	70.8	9.9	397	1.07	3.2
PP-34	100	467.5	537	166	1,815	64	63.4	15.2	242	1.60	4.6
PP-35	100	1,025	642	192	1,940	69	82.5	5.6	511	0.92	2.8
PP-36	100	530.0	629	185	1,592	53	81.3	5.3	277	1.78	5.3
PP-37	100	970.8	802	110	1,740	60	79.1	6.7	493	0.93	1.6
PP-38	100	396.3	759	156	1,993	71	66.0	15.7	208	2.05	4.7
PP-39	100	379.3	553	173	1,462	45	65.1	15.4	197	2.08	6.2
PP-40	100	553.5	516	150	1,547	50	76.9	2.8	287	1.48	3.9
PP-41	100	593.4	759	138	1,950	70	70.8	12.9	298	1.40	2.9
Avg	--	**724.2**	**645**	**157**	**1,763**	**61**	**67.5**	**14.2**	**368**	**1.59**	**4.1**
Max	--	1,640	861	192	2,053	73	82.5	66.4	790	3.32	8.0
Min	--	162.0	472	110	1,462	45	9.5	2.8	83	0.61	1.5
%SD	--	56%	17%	12%	10%	13%	25%	99%	54%	42%	42%

Overall Grinding

Test	Screen Undersize Dens g/L	Screen Undersize Dens. % Sol	Screen Undersize % - 100 m	Net Power kWh/t	Work Index metric
PP-24	--	--	75.2	--	--
PP-25	1,170	21	79.0	--	--
PP-26	1,150	18	74.1	--	--
PP-27	1,237	27	79.8	--	--
PP-28	1,347	37	80.6	6.99	10.5
PP-29	1,274	30	78.5	4.65	7.1
PP-30	1,262	29	81.6	5.15	7.5
PP-31	1,160	20	78.4	3.38	5.2
PP-32	1,191	23	77.8	4.54	7.0
PP-33	1,590	53	70.8	4.14	7.1
PP-34	1,170	21	75.1	4.60	7.4
PP-35	1,150	19	68.4	4.12	7.2
PP-36	1,174	21	69.5	5.14	8.9
PP-37	1,163	20	87.2	4.07	5.1
PP-38	1,200	24	77.6	5.24	8.0
PP-39	1,186	22	73.5	5.34	8.9
PP-40	1,175	21	79.3	4.70	7.1
PP-41	1,173	21	82.0	4.63	6.6
Avg	**1,222**	**25**	**77.1**	**4.76**	**7.4**
Max	1,590	53	87.2	6.99	10.5
Min	1,150	18	68.4	3.38	5.1
%SD	9%	35%	6%	18%	19%

Reagent Summary **Pulp Conditions**

Test	Column Feed			Rougher Feed				1st Scavenger Feed				2nd Scav Feed		Total		Nominal Res. Time			
	NaIX g/t	DF-250 g/t	Pulp pH	NaIX g/t	DF-250 g/t	Pulp pH	Temp deg C	NaIX g/t	DF-250 g/t	CuSO4 g/t	Pulp pH	NaIX g/t	DF-250 g/t	NaIX g/t	DF-250 g/t	Column min	P. Ro min	S. Ro min	Scav min
PP-24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PP-25	--	--	--	84.1	36.5	8.9	19.0	47.1	37.7	64.1	8.0	32.4	23.5	163.6	97.7	--	--	--	--
PP-26	30.6	15.6	--	--	--	9.1	15.5	49.4	12.3	45.7	8.0	34.0	12.3	157.4	65.4	1.9	4.0	1.4	8.9
PP-27	--	--	--	74.1	40.8	9.4	20.0	20.8	15.6	37.6	8.5	28.3	17.3	79.8	48.6	--	5.5	2.4	27.1
PP-28	--	--	--	39.4	23.4	11.5	23.0	24.6	12.3	35.1	11.3	34.5	20.9	98.5	56.6	--	3.7	1.3	7.7
PP-29	--	--	--	44.3	39.4	9.1	24.0	45.6	12.5	37.5	8.4	33.7	25.0	123.7	76.8	--	6.7	3.4	38.7
PP-30	--	--	--	45.4	41.0	9.3	24.0	43.5	11.8	38.5	8.6	33.0	25.5	121.9	78.3	--	6.5	3.2	38.3
PP-31	19.2	30.9	9.8	32.8	16.1	9.4	27.0	43.3	12.4	36.5	8.5	32.2	25.4	127.5	84.8	1.3	4.2	1.4	23.3
PP-32	17.7	29.3	8.5	29.9	17.7	8.0	28.0	42.1	11.6	36.6	7.6	29.9	24.4	119.7	83.0	3.0	5.1	2.8	35.6
PP-33	18.6	32.2	9.6	27.9	19.2	9.3	25.5	45.2	13.6	35.9	8.4	31.0	26.6	122.7	91.7	2.0	6.6	3.2	38.3
PP-34	--	--	--	47.0	45.8	9.3	26.0	43.3	11.6	37.8	8.6	31.1	23.8	121.4	81.2	--	4.1	2.5	32.8
PP-35	17.3	27.5	9.2	28.1	17.3	9.0	27.0	40.0	10.8	35.9	8.7	30.5	24.5	115.9	80.1	1.6	3.8	1.7	25.2
PP-36	18.8	30.8	9.8	32.0	18.2	9.4	24.7	44.0	11.9	38.9	8.4	31.4	25.7	126.2	86.7	2.5	13.6	1.8	44.1
PP-37	--	--	--	51.2	47.6	9.3	24.8	42.6	12.2	37.8	8.7	30.5	25.0	124.3	84.7	--	15.6	2.3	37.0
PP-38	18.3	31.5	9.5	32.1	17.6	8.8	24.0	44.1	12.6	40.3	8.6	31.5	25.2	126.0	86.9	2.5	10.4	2.6	40.2
PP-39	18.7	32.4	9.5	31.1	18.7	9.2	23.0	43.6	12.5	39.2	8.4	31.1	24.9	124.6	88.5	2.9	12.1	3.0	51.2
PP-40	18.1	31.1	9.4	31.1	18.1	9.1	24.0	44.2	12.5	37.4	8.8	29.9	25.5	123.3	87.2	3.1	16.7	2.3	42.4
PP-41	18.7	28.9	10.4	30.8	16.9	10.0	24.0	42.8	12.1	36.2	9.5	30.2	25.9	122.4	83.8	3.2	18.8	2.6	34.7
Avg	**19.6**	**29.0**	**9.5**	**41.3**	**27.1**	**9.3**	**23.7**	**41.5**	**13.9**	**39.5**	**8.6**	**31.5**	**23.6**	**123.5**	**80.1**	**2.4**	**8.6**	**2.4**	**32.8**
Max	30.6	32.4	10.4	84.1	47.6	11.5	28.0	49.4	37.7	64.1	11.3	34.5	26.6	163.6	97.7	3.2	18.8	3.4	51.2
Min	17.3	15.6	8.5	27.9	16.1	8.0	15.5	20.8	10.8	35.1	7.6	28.3	12.3	79.8	48.6	1.3	3.7	1.3	7.7
%S.D.	20%	17%	5%	40%	45%	7%	13%	18%	45%	17%	9%	5%	15%	15%	16%	28%	60%	29%	36%

Metallurgical Summary

Test	General Feed Conditions						Column	Column Concentrate			Prim. Rghr Concentrate			Final	Total Concentrates			Col + P.Rghr		
	% - 100 m	Dens % Sol	NaIX g/t	DF250 g/t	Assay % Ni	Assay % Cu	Feed kg/h	Mass Wt %	Assay % Ni	Rec'y Ni	Mass Wt %	Assay % Ni	Rec'y Ni	Tails % Ni	Mass Wt %	Assay % Ni	Rec'y Ni	Mass Wt %	Assay % Ni	Rec'y Ni
PP-24	75.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PP-25	79.0	21	163.6	97.7	1.51	0.66	--	--	--	--	18.9	5.13	64.2	0.41	27.6	4.59	83.8	18.9	5.13	64.2
PP-26	74.1	18	157.4	65.4	1.39	0.62	1,135	9.0	7.48	48.3	5.7	3.87	15.9	0.18	31.3	4.07	91.2	14.7	6.08	64.3
PP-27	79.8	27	79.8	48.6	1.36	0.61	--	--	--	--	3.8	8.87	24.8	0.26	28.5	4.14	86.5	3.8	8.87	24.8
PP-28	80.6	37	98.5	56.6	1.39	0.64	--	--	--	--	4.3	6.31	19.7	1.16	4.8	6.10	20.9	4.3	6.31	19.7
PP-29	78.5	30	123.7	76.8	1.46	0.68	--	--	--	--	11.7	6.49	51.8	0.22	39.7	3.35	90.9	11.7	6.49	51.8
PP-30	81.6	29	121.9	78.3	1.37	0.66	--	--	--	--	11.0	6.46	52.2	0.22	37.0	3.32	89.7	11.0	6.46	52.2
Avg	**78.4**	**27**	**124.2**	**70.6**	**1.41**	**0.65**	**1,135**	**9.0**	**7.5**	**48.3**	**9.2**	**6.19**	**38.1**	**0.41**	**28.2**	**4.26**	**77.2**	**10.7**	**6.56**	**46.2**
Max	81.6	37	163.6	97.7	1.51	0.68	--	--	--	--	18.9	8.87	64.2	1.16	39.7	6.10	91.2	18.9	8.87	64.3
Min	74.1	18	79.8	48.6	1.36	0.61	--	--	--	--	3.8	3.87	15.9	0.18	4.8	3.32	20.9	3.8	5.13	19.7
%SD	4%	25%	26%	25%	4%	4%	--	--	--	--	63%	27%	53%	92%	44%	24%	36%	55%	19%	42%
PP-31	78.4	20	127.5	84.8	1.55	0.62	1,519	6.8	5.60	24.7	6.3	4.64	18.9	0.51	29.0	4.10	76.7	13.1	5.14	43.5
PP-32	77.8	23	119.7	83.0	1.40	0.64	642.9	8.1	7.40	42.5	5.8	5.21	21.6	0.20	34.4	3.69	90.5	13.9	6.53	64.6
PP-33	70.8	20	122.7	91.7	1.39	0.58	961.5	2.4	5.21	8.9	9.4	4.23	28.8	0.27	36.5	3.33	87.6	11.8	4.43	37.7
PP-34	75.1	21	121.4	81.2	1.25	0.59	--	--	--	--	11.1	6.87	61.3	0.19	33.6	3.33	89.7	11.1	6.87	61.3
PP-35	68.4	19	115.9	80.1	1.24	0.60	1,096	7.6	6.96	42.6	6.7	5.07	27.6	0.15	32.0	3.54	91.6	14.3	6.06	70.0
PP-36	69.5	21	126.2	86.7	1.29	0.62	721.1	6.4	7.97	39.7	8.0	4.60	28.6	0.15	35.1	3.40	92.4	14.5	6.10	68.3
PP-37	87.2	20	124.3	84.7	1.24	0.63	--	--	--	--	14.3	5.83	67.1	0.13	33.0	3.49	92.9	14.3	5.83	67.1
PP-38	77.6	24	126.0	86.9	1.30	0.52	586.8	0.9	6.55	4.8	13.5	5.62	58.8	0.16	36.3	3.29	92.0	14.5	5.67	63.5
PP-39	73.5	22	124.6	88.5	1.33	0.63	572.0	2.3	7.59	13.4	11.9	5.89	52.5	0.15	36.8	3.35	92.8	14.2	6.17	65.8
PP-40	79.3	21	123.3	87.2	1.36	0.63	723.9	3.6	8.56	22.5	13.6	4.97	50.2	0.21	29.1	4.14	89.2	17.2	5.71	72.7
PP-41	82.0	21	122.4	83.8	1.43	0.60	792.4	7.9	6.56	36.1	9.1	5.31	33.6	0.21	34.7	3.74	90.3	17.0	5.86	69.4
Avg	**76.3**	**21**	**123.1**	**85.3**	**1.34**	**0.61**	**846.1**	**5.1**	**6.93**	**26.1**	**10.0**	**5.29**	**40.8**	**0.21**	**33.7**	**3.58**	**89.6**	**14.2**	**5.85**	**62.2**
Max	87.2	24	127.5	91.7	1.55	0.64	1,519	8.1	8.56	42.6	14.3	6.87	67.1	0.51	36.8	4.14	92.9	17.2	6.87	72.7
Min	68.4	19	115.9	80.1	1.24	0.52	572.0	0.90	5.21	4.80	5.80	4.23	18.9	0.13	29.00	3.29	76.7	11.10	4.43	37.7
%SD	7%	7%	3%	4%	7%	6%	36%	55%	16%	57%	31%	14%	43%	50%	8%	8%	5%	13%	11%	18%

Summary of Unit Performance

Test	Unit Column Cell					Primary Rougher					Secondary Rougher					Scavenger				
	Concentrate		Unit Recov		Ratio	Concentrate		Unit Recov		Ratio	Concentrate		Unit Recov		Ratio	Concentrate		Unit Recov		Ratio
	% Ni	% Pn	Ni	Pn	Po/Pn	% Ni	% Pn	Ni	Pn	Po/Pn	% Ni	% Pn	Ni	Pn	Po/Pn	% Ni	% Pn	Ni	Pn	Po/Pn
PP-24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PP-25	--	--	--	--	--	5.13	12.8	65.4	--	--	3.41	--	44.5	95.0	--	--	--	--	--	--
PP-26	7.48	19.2	19.6	21.5	3.0	3.87	9.61	30.9	33.1	5.3	3.33	8.58	16.6	19.1	3.4	2.08	4.23	70.4	65.9	19.8
PP-27	--	--	--	--	--	8.87	22.9	24.8	25.8	1.9	9.50	25.0	21.6	23.3	1.5	2.77	6.57	77.2	76.6	9.1
PP-28	--	--	--	--	--	6.31	15.6	19.7	20.1	2.4	4.12	10.2	1.5	1.6	4.9	--	--	--	--	--
PP-29	--	--	--	--	--	6.49	16.5	51.8	53.8	3.4	3.99	9.84	7.3	7.8	6.0	1.95	4.39	79.5	77.0	12.4
PP-30	--	--	--	--	--	6.46	16.6	52.2	54.8	2.8	3.83	9.57	11.4	12.3	5.3	1.83	4.00	75.8	72.5	14.5
PP-31	5.60	14.0	7.0	7.6	4.1	4.64	11.7	25.1	25.5	4.5	4.37	11.1	7.7	7.9	4.4	3.12	7.22	55.4	52.3	10.6
PP-32	7.40	19.0	25.7	28.0	2.9	5.21	13.2	37.5	40.3	4.0	3.55	8.97	5.7	6.4	4.3	1.70	3.55	71.5	66.9	17.8
PP-33	5.21	12.9	3.4	3.6	3.9	4.23	10.5	31.6	32.1	5.0	4.78	12.1	8.0	8.4	4.2	2.68	6.31	78.4	76.7	9.6
PP-34	--	--	--	--	--	6.87	17.8	61.3	64.6	2.6	3.96	10.0	2.6	3.0	4.3	1.54	3.21	72.6	68.1	17.8
PP-35	6.96	18.0	17.7	20.2	2.4	5.07	12.9	47.9	52.2	3.9	3.35	8.19	4.2	4.8	6.5	1.46	2.83	70.8	64.6	23.4
PP-36	7.97	20.5	22.0	24.0	2.6	4.60	11.6	47.4	51.0	4.6	2.97	7.12	4.9	5.4	7.9	1.46	2.95	74.8	69.9	20.3
PP-37	--	--	--	--	--	5.83	14.9	67.1	70.3	3.0	3.33	8.29	3.6	4.0	5.4	1.65	3.45	77.4	73.7	17.7
PP-38	6.55	16.5	2.8	3.0	3.0	5.62	14.5	61.7	65.2	3.1	3.63	9.09	1.7	1.9	4.7	1.68	3.54	77.8	74.1	17.1
PP-39	7.59	19.2	8.3	8.9	2.0	5.89	15.2	60.5	64.6	3.2	3.06	7.61	1.8	2.1	5.4	1.57	3.22	78.6	74.6	19.3
PP-40	8.56	21.7	11.8	12.6	3.0	4.97	12.4	64.8	64.7	5.3	3.52	9.03	10.8	11.1	3.7	1.82	4.38	59.5	57.8	7.9
PP-41	6.56	16.6	18.8	20.4	3.7	5.31	13.4	52.6	54.0	4.4	3.69	9.31	6.3	6.6	4.6	1.61	3.70	66.3	63.6	11.1
Avg	**6.99**	**17.7**	**13.7**	**15.0**	**3.06**	**5.61**	**14.2**	**47.2**	**48.3**	**3.71**	**4.02**	**10.3**	**9.42**	**13.0**	**4.78**	**1.93**	**4.24**	**72.4**	**69.0**	**15.2**
Max	8.56	21.7	25.7	28.0	4.10	8.87	22.9	67.1	70.3	5.30	9.50	25.0	44.5	95.0	7.90	3.12	7.22	79.5	77.0	23.4
Min	5.21	12.9	2.80	3.00	2.00	3.87	9.61	19.7	20.1	1.90	2.97	7.12	1.50	1.60	1.50	1.46	2.83	55.4	52.3	7.90
%S.D.	15%	16%	59%	60%	22%	21%	22%	34%	34%	29%	37%	40%	112%	169%	30%	27%	32%	10%	11%	32%

Summary of Unit Column, Primary Rougher and Combined Concentrates

Test	Unit Column Cell								Primary Rougher								Combined Concentrate						
	F80	Mass	Grade		Recovery		Ratio	P80	F80	Mass	Grade		Recovery		Ratio	P80	Mass	Grade		Recovery		Ratio	P80
	µm	Wt%	%Ni	%Pn	Ni	Pn	Po/Pn	µm	µm	Wt%	%Ni	%Pn	Ni	Pn	Po/Pn	µm	Wt%	%Ni	%Pn	Ni	Pn	Po/Pn	µm
24	--	--	--	--	--	--	--	--	165	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25	--	--	--	--	--	--	--	--	151	18.9	5.13	12.8	64.2	65.4	4.9	86	27.6	4.59	3.70	83.8	84.9	5.5	79
26	781	9.0	7.48	19.2	48.3	50.9	3.0	122	169	5.7	3.87	9.61	15.9	16.2	5.3	70	31.3	4.07	9.89	91.2	90.9	6.6	129
27	--	--	--	--	--	--	--	--	148	3.8	8.87	22.9	24.8	25.8	1.9	71	28.5	4.14	10.3	86.5	86.7	5.4	125
28	--	--	--	--	--	--	--	--	145	4.3	6.31	15.6	19.7	20.1	2.4	83	4.8	6.10	15.2	20.9	21.3	2.5	78
29	--	--	--	--	--	--	--	--	153	11.7	6.49	16.5	51.8	53.8	3.4	90	39.7	3.35	8.13	90.9	90.2	6.8	161
30	--	--	--	--	--	--	--	--	140	11.0	6.46	16.6	52.2	54.8	2.8	95	37.0	3.32	8.04	89.7	89.1	6.7	169
31	656	6.8	5.60	14.0	24.7	24.8	4.1	90	153	6.3	4.64	11.7	18.9	19.2	4.5	159	29.0	4.10	9.98	76.7	75.4	6.5	--
32	650	8.1	7.40	19.0	42.5	44.6	2.9	86	155	5.8	5.21	13.2	21.6	22.3	4.0	105	34.4	3.69	8.99	90.5	90.0	6.6	--
33	746	2.4	5.21	12.9	8.9	9.0	3.9	90	181	9.4	4.23	10.5	28.8	29.2	5.0	181	36.5	3.33	8.05	87.6	93.8	7.1	--
34	--	--	--	--	--	--	--	--	166	11.1	6.87	17.8	61.3	64.6	2.6	113	33.6	3.33	8.10	89.7	93.7	6.6	--
35	896	7.6	6.96	18.0	42.6	45.1	2.4	105	192	6.7	5.07	12.9	27.6	28.7	3.9	166	32.0	3.54	8.59	91.6	91.2	6.7	--
36	868	6.4	7.97	20.5	39.7	42.0	2.6	102	185	8.0	4.60	11.6	28.6	29.6	4.6	164	35.1	3.40	8.22	92.4	91.9	6.9	--
37	--	--	--	--	--	--	--	--	110	14.3	5.83	14.9	67.1	70.3	3.0	124	33.0	3.49	8.51	92.9	92.6	6.4	--
38	754	0.9	6.55	16.5	4.8	4.9	3.0	88	156	13.5	5.62	14.5	58.8	62.0	3.1	119	36.3	3.29	7.99	92.0	91.6	6.8	--
39	668	2.3	7.59	19.2	13.4	13.9	2.0	88	173	11.9	5.89	15.2	52.5	55.7	3.2	105	36.8	3.35	8.11	92.8	92.4	6.9	--
40	705	3.6	8.56	21.7	22.5	22.8	3.0	109	150	13.6	4.97	12.4	50.2	50.0	5.3	132	29.1	4.14	10.3	89.2	88.7	5.1	--
41	753	7.9	6.56	16.6	36.1	36.8	3.7	79	138	9.1	5.31	13.4	33.6	34.2	4.4	123	34.7	3.74	9.27	90.3	90.0	5.5	--
Avg	**744**	**5.1**	**6.93**	**17.6**	**26.1**	**27.1**	**3.1**	**93**	**160**	**10.0**	**5.29**	**13.5**	**40.8**	**42.3**	**4.0**	**136**	**34**	**3.58**	**8.74**	**89.6**	**90.1**	**6.46**	
Max	896	8.1	7.97	20.5	42.6	45.1	4.1	105	192	14.3	6.87	17.8	67.1	70.3	5.0	181	37	4.10	9.98	92.9	93.8	7.10	
Min	650	0.9	5.21	12.9	4.8	4.9	2.4	86	110	5.8	4.23	10.5	18.9	19.2	2.6	105	29	3.29	7.99	76.7	75.4	6.40	
%SD	11%	57%	15%	16%	60%	61%	22%	14%	12%	41%	22%	23%	44%	44%	27%	25%	23%	20%	25%	19%	19%	17%	

Summary of Column Flotation (Wash constant at 1.33 L/min. Bias constant at 0.13 cm/s)

Test	Feed Conditions				Operating Conditions									Tails			Concentrate			
	CLR	Solids	Pulp	K80	Level	Volume	NRT	Holdup	Gas	Gas	Tails	Conc	Loading	Pulp	Density		P80	Grade	Grade	Recov
	%	tph	L/min	µm	cm	L	min	%	L/min	cm/s	cm/s	kg/h	g/min/cm2	L/min	g/L	%Sol	µm	%Ni	%Pn	Ni%
PP-26	484	1,135	13.5	781	26.7	37.9	3.1	33.8	6.97	0.66	1.15	17.5	1.65	12.2	1,435	47.6	122	7.48	19.2	48.3
PP-31	683	1,519	14.7	656	25.0	38.2	2.8	42.6	10.7	1.01	1.26	13.2	1.24	13.4	1,580	57.7	90	5.60	14.0	24.7
PP-32	227	642.9	14.1	650	44.0	34.8	2.7	35.9	8.09	0.76	1.21	15.9	1.50	12.8	1,550	55.8	86	7.40	19.0	42.5
PP-33	397	961.5	14.8	746	37.0	36.0	2.7	33.3	9.46	0.89	1.27	4.6	0.43	13.5	1,503	52.6	90	5.21	12.9	8.9
PP-35	511	1,096	17.3	896	46.0	34.5	2.2	42.3	9.17	0.86	1.51	15.2	1.43	16.0	1,605	59.2	105	6.96	18.0	42.6
PP-36	277	721.1	14.2	868	50.0	33.7	2.6	32.2	6.72	0.63	1.22	12.3	1.16	12.9	1,512	53.2	102	7.97	20.5	39.7
PP-38	208	586.8	14.6	754	46.0	34.5	2.6	28.6	6.96	0.66	1.25	1.8	0.17	13.3	1,407	45.5	88	6.55	16.5	4.8
PP-39	197	572.0	13.1	668	48.0	34.1	2.9	29.4	8.57	0.81	1.11	4.5	0.42	11.8	1,500	52.4	88	7.59	19.2	13.4
PP-40	287	723.9	16.4	705	46.0	34.5	2.3	39.1	9.69	0.91	1.42	6.9	0.65	15.1	1,650	61.9	109	8.56	21.7	22.8
PP-41	298	792.4	13.0	753	46.0	34.5	2.9	40.0	10.7	1.01	1.10	15.7	1.48	11.7	1,667	62.9	79	6.56	16.6	36.1
Avg	**357**	**875.1**	**14.6**	**748**	**41.5**	**35.3**	**2.7**	**35.7**	**8.7**	**0.82**	**1.25**	**10.8**	**1.01**	**13.3**	**1.541**	**54.9**	**96**	**6.99**	**17.8**	**28.4**
Max	683	1,519	17.3	896	50.0	38.2	3.1	42.6	10.7	1.01	1.51	17.5	1.65	16.0	1,667	62.9	122	8.56	21.7	48.3
Min	197	572.0	13.0	650	25.0	33.7	2.2	28.6	6.7	0.63	1.10	1.8	0.17	11.7	1,407	45.5	79	5.21	12.9	4.8
%SD	45%	35%	9%	11%	21%	4%	11%	14%	17%	17%	10%	53%	53%	10%	6%	10%	14%	15%	16%	55%

Mill Feed Summary

Rod Mill Summary

Test	Mill Feed					Rod Charge kg	Screen Size mesh	Feed K80 µm	Disch. K80 µm	Rod Mill Discharge			Net Power kWh/t	Work Index metric
	Wet kg/h	Dry kg/h	Moist %	Shift kg	Total tonnes					Density g/L	% + 48 m	% - 100 m		
PP-1	194.8	189.8	2.6	1,299	1.3	200	80	4,093	492	1,606	39.7	38.2	3.09	10.5
PP-2	194.9	190.4	2.3	975	2.3	150	60	4,033	607	1,585	46.6	34.6	2.53	10.2
PP-3	198.3	194.8	1.8	1,355	3.6	100	24	4,283	1,049	1,578	60.2	26.9	1.82	11.6
PP-4	192.6	188.2	2.3	1,252	4.9	100	24	3,958	912	1,602	57.5	28.4	2.27	13.2
PP-5	192.6	187.9	2.4	1,445	6.3	100	24	4,076	906	1,598	56.7	29.2	2.27	12.9
PP-6	196.8	192.6	2.1	1,295	7.6	100	24	3,993	986	1,617	59.2	26.5	2.10	13.1
PP-7	197.2	192.5	2.4	1,430	9.1	100	24	4,144	1,012	1,604	59.1	28.0	2.16	13.6
PP-8	200.4	195.8	2.3	1,002	10.1	100	24	4,145	1,065	1,607	61.2	26.1	2.04	13.5
PP-9	204.8	200.0	2.3	1,468	11.5	100	24	3,925	990	1,590	57.1	29.6	2.12	13.4
PP-11	198.1	193.4	2.4	1,288	12.8	100	24	4,018	1,028	1,616	59.7	27.3	2.02	13.1
PP-13	193.2	189.4	2.0	1,352	14.2	100	24	3,959	779	1,692	53.7	31.2	2.06	10.3
PP-14	193.1	189.2	2.0	772	14.9	100	24	3,658	975	1,670	58.3	27.9	1.64	10.6
PP-15	197.8	193.7	2.1	1,335	16.3	100	24	4,048	951	1,603	57.4	28.7	1.64	9.8
PP-16	192.3	188.3	2.1	1,298	17.6	100	24	4,237	992	1,626	57.8	28.8	1.71	10.4
PP-18	185.3	180.9	2.4	1,297	18.9	100	24	3,328	969	1,603	58.1	28.4	1.86	12.6
PP-19	193.4	190.4	1.6	1,064	19.9	100	24	4,467	1,128	1,647	60.9	26.9	1.50	10.1
PP-20	190.5	187.1	1.8	1,334	21.3	100	24	4,094	992	1,606	59.5	27.4	1.65	10.3
PP-21	190.0	186.5	1.8	855	22.1	100	24	4,230	1,105	1,598	60.7	27.1	1.69	11.5
PP-22	198.5	195.1	1.7	828	22.9	100	24	3,707	984	1,605	59.0	27.9	2.04	13.2
PP-23	191.8	188.7	1.6	992	23.9	100	24	4,107	1,106	1,630	60.7	26.8	2.09	14.5
Avg	**193.1**	**189.3**	**1.9**	**1,129**	**18.6**	**100**	**24**	**3,987**	**1,001**	**1,627**	**58.7**	**28.0**	**1.81**	**11.5**
Max	204.8	200.0	2.6	1,468	23.9	200	80	4,467	1,128	1,692	61.2	38.2	3.09	14.5
Min	185.3	180.9	1.6	772	1.3	100	24	3,328	492	1,578	39.7	26.1	1.50	9.8
%SD	2%	2%	16%	19%	39%	24%	61%	6%	16%	2%	9%	10%	20%	13%

Reagent Summary

Pulp Conditions

Test	Ball Mill Discharge			Rougher			Scavenger			Scav Cell 4		Total			Rougher		Nominal Res. Time			
	PAX g/t	DF-250 g/t	P. Oil g/t	PAX g/t	DF-250 g/t	P. Oil g/t	PAX g/t	DF-250 g/t	P. Oil g/t	PAX g/t	DF-250 g/t	PAX g/t	DF-250 g/t	P. Oil g/t	Alk pH	Temp deg C	Column min	Rghr min	Scav min	Pre-Clr min
PP-1	--	--	--	1.93	1.83	12.0	1.26	2.15	1.11	0.92	1.68	4.1	5.7	13.1	8.2	--	--	13.5	32.1	7.0
PP-2	--	--	--	2.02	1.20	14.2	1.86	1.92	0.98	0.95	1.83	4.8	5.0	15.2	8.2	21.0	--	9.8	25.7	7.0
PP-3	--	--	--	1.91	1.66	13.3	1.94	1.51	0.62	0.86	0.92	4.7	4.1	13.9	8.2	27.0	--	12.7	25.8	7.0
PP-4	--	--	--	1.91	1.31	14.4	3.16	1.28	0.64	0.83	0.89	5.9	3.5	15.0	8.2	21.0	--	13.3	27.2	7.0
PP-5	--	--	--	1.98	1.28	15.0	3.23	1.25	0.64	0.93	0.86	6.1	3.4	15.6	8.2	19.7	--	12.8	27.6	7.0
PP-6	--	--	--	2.18	1.18	15.1	3.12	1.25	0.62	1.12	0.93	6.4	3.4	15.8	8.3	19.0	--	11.4	24.1	7.0
PP-7	--	--	--	2.21	1.59	11.2	3.12	1.25	0.62	1.12	0.84	6.5	3.7	11.9	8.3	15.9	--	14.0	28.3	7.0
PP-8	--	--	--	3.06	1.19	11.3	3.71	1.23	0.61	2.39	0.92	9.2	3.3	11.9	8.4	17.2	--	12.4	25.8	7.0
PP-9	--	--	--	3.60	1.29	10.8	3.63	1.20	0.66	2.43	0.84	9.7	3.3	11.5	8.5	14.9	--	8.2	17.3	7.0
PP-11	0.31	2.17	11.2	1.55	--	--	3.72	0.62	0.62	2.48	1.24	8.1	4.0	11.8	8.0	10.0	2.9	5.4	12.4	7.0
PP-13	3.17	2.53	14.3	1.58	--	--	3.80	0.63	0.63	2.53	1.27	11.1	4.4	14.9	8.4	11.2	3.3	5.6	12.4	7.0
PP-14	3.17	2.54	14.3	1.59	--	--	3.80	0.63	0.63	2.54	1.27	11.1	4.4	14.9	8.0	12.0	2.0	5.3	10.2	7.0
PP-15	3.72	3.10	13.9	2.17	--	--	3.72	0.62	0.62	2.48	1.24	12.1	5.0	14.6	8.0	12.5	3.5	7.6	18.0	7.0
PP-16	3.82	2.55	14.3	2.23	--	--	3.82	0.64	0.64	2.55	1.27	12.4	4.5	15.0	8.1	14.2	4.1	8.1	16.8	7.0
PP-18	3.98	2.65	14.9	2.32	--	--	3.98	0.66	0.66	2.65	1.33	12.9	4.6	15.6	8.0	12.5	2.6	5.4	11.3	7.0
PP-19	3.78	2.52	14.2	2.21	--	--	3.78	0.63	0.63	2.52	1.26	12.3	4.4	14.8	7.8	16.0	3.5	6.3	14.2	7.0
PP-20	3.85	2.57	13.3	2.41	--	--	3.85	0.64	0.64	2.57	1.25	12.7	4.5	13.9	8.0	16.0	--	6.1	13.6	7.0
PP-21	3.86	2.57	14.5	2.25	--	--	3.86	0.64	0.64	2.57	1.29	12.5	4.5	15.1	8.1	15.0	3.0	5.5	9.5	7.0
PP-22	3.63	2.43	12.5	2.15	--	--	3.69	0.61	0.61	2.49	1.17	12.0	4.2	13.1	8.0	15.0	1.7	4.3	9.7	7.0
PP-23	3.78	2.61	15.2	2.45	--	--	3.81	0.64	0.64	2.51	1.21	12.6	4.5	15.8	8.0	15.3	1.9	4.5	8.8	7.0
Avg	3.37	2.57	13.9	2.19	1.39	13.0	3.34	1.00	0.67	1.97	1.18	9.4	4.2	14.2	8.1	16.1	2.9	8.6	18.5	7.0
Max	3.98	3.10	15.2	3.60	1.83	15.1	3.98	2.15	1.11	2.65	1.83	12.9	5.7	15.8	8.5	27.0	4.1	14.0	32.1	7.0
Min	0.31	2.17	11.2	1.55	1.18	10.8	1.26	0.61	0.61	0.83	0.84	4.1	3.3	11.5	7.8	10.0	1.7	4.3	8.8	7.0
%SD	31%	8%	8%	22%	17%	13%	23%	47%	19%	39%	23%	34%	15%	10%	2%	25%	28%	41%	41%	0%

Summary of Unit Performance

Test	Unit Column Cell			Rougher			Scavenger			Pre-Cleaner			Cleaner			Cleaner/Scavenger		
	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.
PP-1	--	--	--	6.60	75.5	54.3	2.88	38.2	60.2	31.1	72.2	93.7	10.5	2.50	52.0	1.81	1.5	65.8
PP-2	--	--	--	1.31	76.1	53.9	0.41	32.8	50.3	25.5	62.0	73.3	11.3	5.20	23.0	2.47	8.6	49.2
PP-3	--	--	--	7.34	51.8	40.9	12.2	25.3	33.8	38.1	48.0	92.3	9.00	2.50	63.4	4.31	0.2	14.8
PP-4	--	--	--	7.29	74.2	48.7	2.07	49.7	62.9	38.3	64.4	86.2	31.5	6.10	60.6	15.8	1.4	33.9
PP-5	--	--	--	3.44	69.8	55.3	1.26	23.0	40.7	39.8	50.4	72.4	29.3	16.0	61.0	1.30	0.8	19.3
PP-6	--	--	--	3.51	68.7	40.9	1.05	59.8	60.6	37.1	49.4	67.1	26.4	12.1	55.8	23.4	1.9	19.2
PP-7	--	--	--	18.0	64.0	47.9	4.99	33.0	47.3	40.0	60.7	93.7	26.3	2.40	55.7	6.74	0.7	45.0
PP-8	--	--	--	20.1	69.8	53.3	6.99	30.3	50.2	38.0	67.7	94.5	29.3	2.30	57.7	7.50	0.9	52.7
PP-9	--	--	--	11.2	69.1	39.2	2.64	70.6	66.0	39.1	59.1	80.8	36.9	5.40	38.1	2.79	4.1	47.3
PP-11	41.4	12.1	8.8	23.5	56.0	44.0	4.92	25.5	35.8	42.8	51.1	86.2	31.1	3.1	38.6	2.81	3.3	65.7
PP-13	42.7	17.5	14.0	22.6	47.4	42.3	2.57	28.8	44.4	40.6	44.5	93.7	28.2	2.0	64.8	19.20	0.1	4.2
PP-14	51.1	16.8	12.5	20.8	45.4	35.1	5.20	46.6	55.3	23.8	44.6	96.1	27.0	0.6	33.4	2.81	0.9	73.2
PP-15	43.9	56.4	41.7	5.10	32.7	51.8	3.55	17.7	60.9	11.1	32.3	93.5	12.1	0.1	1.3	3.23	0.3	12.3
PP-16	47.2	23.0	15.4	25.9	39.7	35.6	4.67	34.2	47.6	32.9	39.1	98.2	30.6	0.4	52.4	11.3	0.1	11.1
PP-18	48.1	41.3	33.1	15.2	26.4	28.0	3.44	34.9	51.4	35.5	24.3	87.5	33.4	1.2	35.1	4.91	1.4	57.5
PP-19	43.2	26.8	20.0	22.8	38.0	40.9	2.04	19.0	34.6	34.3	37.3	98.2	24.0	0.1	10.5	12.3	0.1	12.0
PP-20	--	--	--	16.2	58.5	44.2	2.02	29.7	40.2	39.7	53.1	87.7	28.3	2.7	36.2	10.4	2.0	42.7
PP-21	48.1	32.7	25.3	37.8	39.4	58.6	1.53	62.8	69.3	38.1	38.6	93.6	29.1	0.9	33.5	11.3	0.7	37.1
PP-22	42.1	28.4	11.7	24.9	14.1	12.4	3.92	41.9	42.1	41.9	13.5	94.7	32.2	0.4	57.6	9.50	0.2	49.9
PP-23	41.3	36.2	16.2	10.4	26.3	37.4	2.04	4.90	11.2	39.5	23.4	79.3	27.6	1.2	19.9	8.36	3.2	66.2
Avg	**44.9**	**29.1**	**19.9**	**20.5**	**38.5**	**39.1**	**3.26**	**31.5**	**44.8**	**34.6**	**36.5**	**91.7**	**27.6**	**1.2**	**34.8**	**8.73**	**1.1**	**39.3**
Max	51.1	56.4	41.7	37.8	76.1	58.6	12.2	70.6	69.3	42.8	72.2	98.2	36.9	16.0	64.8	23.4	8.6	73.2
Min	41.3	12.1	8.8	1.3	14.1	12.4	0.41	4.9	11.2	11.1	13.5	67.1	9.0	0.1	1.3	1.30	0.1	4.2
%SD	8%	45%	53%	47%	49%	28%	80%	51%	31%	22%	43%	10%	30%	355%	53%	70%	180%	56%

Volume

2

CONTRACT SERIAL NO. 99131-01-SQ

CONTRACT REQUISITION NO. 23440-9-9131

CONTRACTOR: LAKEFIELD RESEARCH

UNIT COLUMN FLOTATION

Of Highland Valley Copper
and
Falconbridge Strathcona Ores

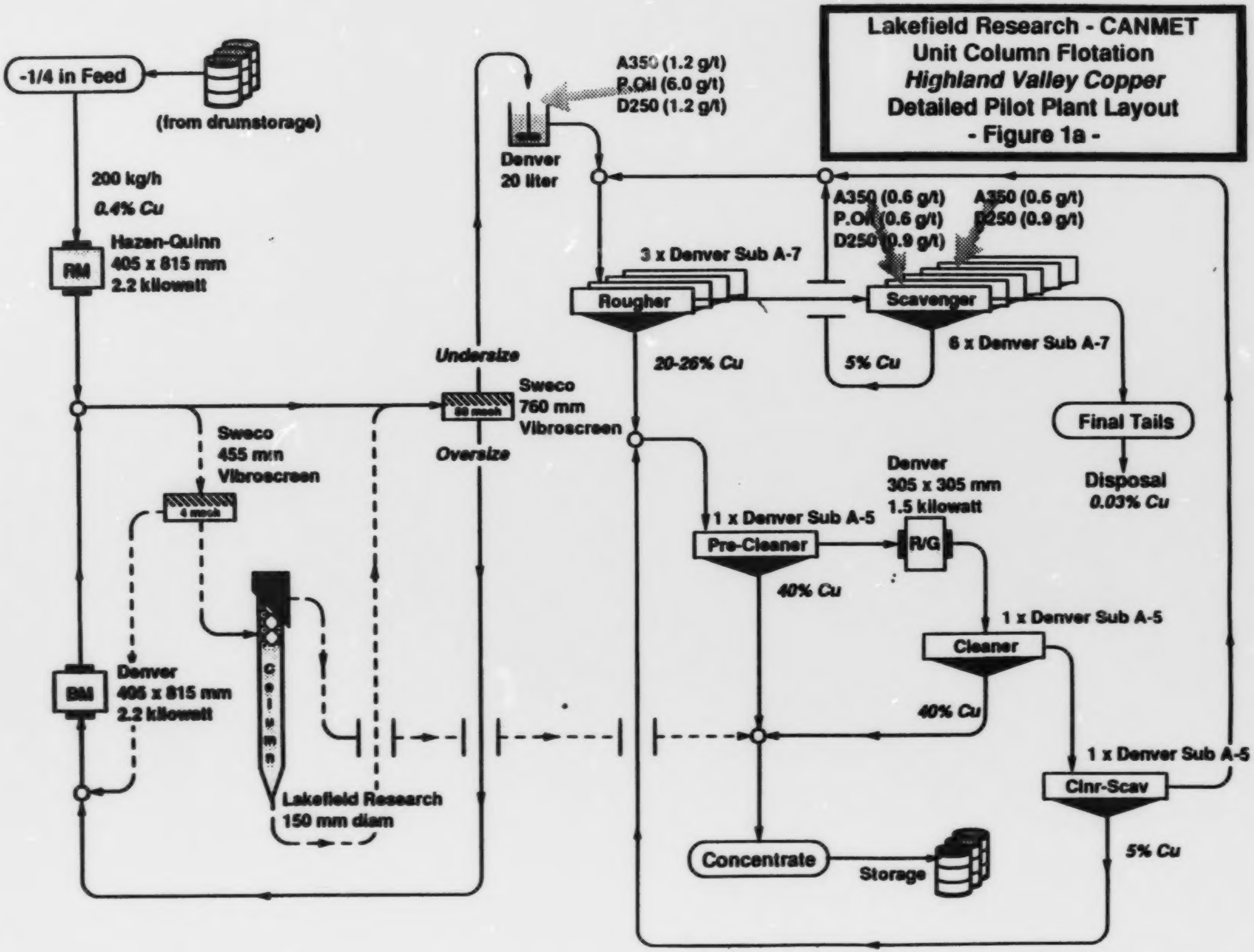
Volume 2 - Final Report

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology (CANMET), Energy Mines and Resources, Canada

Lakefield Research Project Number: LR-3897

DSS File Number	:	003SQ.23440-9-9131
DSS Contract Number	:	23440-9-9131/01-SQ
CANMET Scientific Authority	:	Kwang S. Moon, PhD.

LAKEFIELD RESEARCH
A Division of Falconbridge Limited
December 18th, 1990



Lakefield Research - CANMET
Unit Column Flotation
Highland Valley Copper
Detailed Pilot Plant Layout
- Figure 1a -

LAKEFIELD RESEARCH

Table 1a - Phase One Equipment List

Rod Mill	Hazen-Quinn 405 mm x 815 mm 2.2 kilowatt
Ball Mill	Denver 405 mm x 815 mm 2.2 kilowatt
Primary Screen	Sweco Vibroscreen 760 mm diameter
Unit Column	Lakefield Research 150 mm diameter 3.65 meter high 65 liter
Primary Conditioner	Denver 20 liter
Rougher Flotation	3 x Denver Sub A-7 28 liter per cell 0.37 kW per cell
Scavenger Flotation	6 x Denver Sub A-7 28 liter per cell 0.37 kW per cell
Pre-Cleaner Flotation	1 x Denver Sub A-5 7.7 liter per cell 0.19 kW per cell
Regrind Ball Mill	Denver 305 mm x 305 mm 1.5 kilowatt
Cleaner Flotation	1 x Denver Sub A-5 7.7 liter per cell 0.19 kW per cell
Cleaner Scavenger	1 x Denver Sub A-5 7.7 liter per cell 0.19 kW per cell

Mill Feed Summary

Rod Mill Summary

Test	Mill Feed					Rod Charge kg	Screen Size mesh	Feed K80 µm	Disch. K80 µm	Rod Mill Discharge			Net Power kWh/t	Work Index metric
	Wet kg/h	Dry kg/h	Moist %	Shift kg	Total tonnes					Density g/L	% + 48 m	% - 100 m		
PP-1	194.8	189.8	2.6	1,299	1.3	200	80	4,093	492	1,606	39.7	38.2	3.09	10.5
PP-2	194.9	190.4	2.3	975	2.3	150	60	4,033	607	1,585	46.6	34.6	2.53	10.2
PP-3	198.3	194.8	1.8	1,355	3.6	100	24	4,283	1,049	1,578	60.2	26.9	1.82	11.6
PP-4	192.6	188.2	2.3	1,252	4.9	100	24	3,958	912	1,602	57.5	28.4	2.27	13.2
PP-5	192.6	187.9	2.4	1,445	6.3	100	24	4,076	906	1,598	56.7	29.2	2.27	12.9
PP-6	196.8	192.6	2.1	1,295	7.6	100	24	3,993	986	1,617	59.2	26.5	2.10	13.1
PP-7	197.2	192.5	2.4	1,430	9.1	100	24	4,144	1,012	1,604	59.1	28.0	2.16	13.6
PP-8	200.4	195.8	2.3	1,002	10.1	100	24	4,145	1,065	1,607	61.2	26.1	2.04	13.5
PP-9	204.8	200.0	2.3	1,468	11.5	100	24	3,925	990	1,590	57.1	29.6	2.12	13.4
PP-11	198.1	193.4	2.4	1,288	12.8	100	24	4,018	1,028	1,616	59.7	27.3	2.02	13.1
PP-13	193.2	189.4	2.0	1,352	14.2	100	24	3,959	779	1,692	53.7	31.2	2.06	10.3
PP-14	193.1	189.2	2.0	772	14.9	100	24	3,658	975	1,670	58.3	27.9	1.64	10.6
PP-15	197.8	193.7	2.1	1,335	16.3	100	24	4,048	951	1,603	57.4	28.7	1.64	9.8
PP-16	192.3	188.3	2.1	1,298	17.6	100	24	4,237	992	1,626	57.8	28.8	1.71	10.4
PP-18	185.3	180.9	2.4	1,297	18.9	100	24	3,328	969	1,603	58.1	28.4	1.86	12.6
PP-19	193.4	190.4	1.6	1,064	19.9	100	24	4,467	1,128	1,647	60.9	26.9	1.50	10.1
PP-20	190.5	187.1	1.8	1,334	21.3	100	24	4,094	992	1,606	59.5	27.4	1.65	10.3
PP-21	190.0	186.5	1.8	855	22.1	100	24	4,230	1,105	1,598	60.7	27.1	1.69	11.5
PP-22	198.5	195.1	1.7	828	22.9	100	24	3,707	984	1,605	59.0	27.9	2.04	13.2
PP-23	191.8	188.7	1.6	992	23.9	100	24	4,107	1,106	1,630	60.7	26.8	2.09	14.5
Avg	**193.1**	**189.3**	**1.9**	**1,129**	**18.6**	**100**	**24**	**3,987**	**1,001**	**1,627**	**58.7**	**28.0**	**1.81**	**11.5**
Max	204.8	200.0	2.6	1,468	23.9	200	80	4,467	1,128	1,692	61.2	38.2	3.09	14.5
Min	185.3	180.9	1.6	772	1.3	100	24	3,328	492	1,578	39.7	26.1	1.50	9.8
%SD	2%	2%	16%	19%	39%	24%	61%	6%	16%	2%	9%	10%	20%	13%

Ball Mill Summary

Test	Ball Charge kg	Feed Rate kg/h	Feed K80 µm	Final K80 µm	Ball Mill Discharge Density g/L	Ball Mill Discharge Density % Sol	Ball Mill Discharge % + 48 m	Ball Mill Discharge % - 100 m	Circ Load %	Net Power kWh/t	Work Index metric
PP-1	200	314.4	492	137	1,642	61	5.4	65.6	166	2.32	5.7
PP-2	150	340.4	607	243	1,658	62	5.6	79.4	179	1.56	6.6
PP-3	150	234.5	1,049	314	1,659	62	52.1	29.9	120	2.27	8.9
PP-4	150	179.4	912	281	1,636	61	40.1	36.1	95	2.95	11.1
PP-5	150	144.6	906	281	1,656	62	35.4	40.4	77	3.63	13.7
PP-6	150	197.8	986	310	1,713	64	50.5	31.8	103	2.78	11.1
PP-7	150	180.1	1,012	307	1,639	62	49.7	30.8	94	3.02	11.8
PP-8	150	308.5	1,065	274	1,644	62	62.5	22.9	158	1.77	5.9
PP-9	150	692.3	990	434	1,624	61	83.2	8.8	346	0.79	4.9
PP-11	150	111.8	1,028	289	1,621	60	7.5	80.6	58	1.07	17.6
PP-13	150	85.7	1,269	302	1,568	57	22.5	52.1	45	6.50	22.1
PP-14	150	108.6	1,283	288	1,524	54	27.1	48.8	57	4.94	15.9
PP-15	150	140.9	1,245	288	1,642	61	38.6	39.2	73	3.90	12.8
PP-16	150	141.0	992	322	1,704	65	51.6	32.4	75	3.75	15.6
PP-18	150	85.7	1,231	332	1,588	58	25.7	49.7	47	6.50	24.6
PP-19	150	122.3	1,128	266	1,610	60	32.1	46.0	64	4.14	13.1
PP-20	150	570.5	1,277	373	1,768	68	61.0	26.8	305	1.06	4.4
PP-21	150	162.1	1,105	396	1,693	64	60.8	29.5	87	3.52	17.5
PP-22	150	1,027	984	448	1,693	64	90.7	6.0	526	0.65	4.2
PP-23	150	639.4	1,106	407	–	–	89.2	6.9	339	0.98	5.0
Avg	153	289.3	1,033	315	1,646	61	44.6	38.2	151	2.91	11.6
Max	200	1,027	1,283	448	1,768	68	90.7	80.6	526	6.50	24.6
Min	150	85.7	492	137	1,524	54	5.4	6.0	45	0.65	4.2
%SD	7%	87%	20%	23%	3%	5%	58%	55%	86%	60%	52%

Regrind

Test	Feed K80 µm	Prod K80 µm
PP-1	38	35
PP-2	51	35
PP-3	125	35
PP-4	73	42
PP-5	54	41
PP-6	55	48
PP-7	16	11
PP-8	25	20
PP-9	16	11
PP-11	25	20
PP-13	37	20
PP-14	32	9
PP-15	74	35
PP-16	35	16
PP-18	30	25
PP-19	30	25
PP-20	150	52
PP-21	30	25
PP-22	35	30
PP-23	19	15
Avg	48	28
Max	150	52
Min	16	9
%SD	74%	46%

Overall Grinding

Test	Screen U/S Dens. % Sol	Screen U/S % - 100 m	Net Power kWh/t	Work Index metric
PP-1	41	83.2	5.41	7.8
PP-2	41	65.4	4.09	8.5
PP-3	38	53.7	4.09	9.9
PP-4	41	57.3	5.22	11.9
PP-5	41	58.9	5.90	13.4
PP-6	40	55.5	4.88	11.9
PP-7	41	54.8	5.18	12.5
PP-8	38	59.9	3.80	8.5
PP-9	29	46.8	2.91	9.1
PP-11	19	57.1	6.89	16.0
PP-13	19	55.6	8.57	20.6
PP-14	18	57.4	6.58	15.5
PP-15	25	55.4	5.54	12.8
PP-16	26	54.5	5.45	13.5
PP-18	18	53.0	8.36	22.3
PP-19	21	60.1	5.64	12.2
PP-20	21	50.9	2.71	7.5
PP-21	20	51.8	5.21	14.9
PP-22	16	46.8	2.69	8.7
PP-23	16	47.6	3.07	9.1
Avg	28	56.3	5.11	12.3
Max	41	83.2	8.57	22.3
Min	16	46.8	2.69	7.5
%SD	36%	14%	33%	33%

Reagent Summary **Pulp Conditions**

Test	Ball Mill Discharge			Rougher			Scavenger			Scav Cell 4		Total			Rougher		Nominal Res. Time			
	PAX g/t	DF-250 g/t	P. Oil g/t	PAX g/t	DF-250 g/t	P. Oil g/t	PAX g/t	DF-250 g/t	P. Oil g/t	PAX g/t	DF-250 g/t	PAX g/t	DF-250 g/t	P. Oil g/t	Alk pH	Temp deg C	Column min	Rghr min	Scav min	Pre-Clr min
PP-1	--	--	--	1.93	1.83	12.0	1.26	2.15	1.11	0.92	1.68	4.1	5.7	13.1	8.2	--	--	13.5	32.1	7.0
PP-2	--	--	--	2.02	1.20	14.2	1.86	1.92	0.98	0.95	1.83	4.8	5.0	15.2	8.2	21.0	--	9.8	25.7	7.0
PP-3	--	--	--	1.91	1.66	13.3	1.94	1.51	0.62	0.86	0.92	4.7	4.1	13.9	8.2	27.0	--	12.7	25.8	7.0
PP-4	--	--	--	1.91	1.31	14.4	3.16	1.28	0.64	0.83	0.89	5.9	3.5	15.0	8.2	21.0	--	13.3	27.2	7.0
PP-5	--	--	--	1.98	1.28	15.0	3.23	1.25	0.64	0.93	0.86	6.1	3.4	15.6	8.2	19.7	--	12.8	27.6	7.0
PP-6	--	--	--	2.18	1.18	15.1	3.12	1.25	0.62	1.12	0.93	6.4	3.4	15.8	8.3	19.0	--	11.4	24.1	7.0
PP-7	--	--	--	2.21	1.59	11.2	3.12	1.25	0.62	1.12	0.84	6.5	3.7	11.9	8.3	15.9	--	14.0	28.3	7.0
PP-8	--	--	--	3.06	1.19	11.3	3.71	1.23	0.61	2.39	0.92	9.2	3.3	11.9	8.4	17.2	--	12.4	25.8	7.0
PP-9	--	--	--	3.60	1.29	10.8	3.63	1.20	0.66	2.43	0.84	9.7	3.3	11.5	8.5	14.9	--	8.2	17.3	7.0
PP-11	0.31	2.17	11.2	1.55	--	--	3.72	0.62	0.62	2.48	1.24	8.1	4.0	11.8	8.0	10.0	2.9	5.4	12.4	7.0
PP-13	3.17	2.53	14.3	1.58	--	--	3.80	0.63	0.63	2.53	1.27	11.1	4.4	14.9	8.4	11.2	3.3	5.6	12.4	7.0
PP-14	3.17	2.54	14.3	1.59	--	--	3.80	0.63	0.63	2.54	1.27	11.1	4.4	14.9	8.0	12.0	2.0	5.3	10.2	7.0
PP-15	3.72	3.10	13.9	2.17	--	--	3.72	0.62	0.62	2.48	1.24	12.1	5.0	14.6	8.0	12.5	3.5	7.6	18.0	7.0
PP-16	3.82	2.55	14.3	2.23	--	--	3.82	0.64	0.64	2.55	1.27	12.4	4.5	15.0	8.1	14.2	4.1	8.1	16.8	7.0
PP-18	3.98	2.65	14.9	2.32	--	--	3.98	0.66	0.66	2.65	1.33	12.9	4.6	15.6	8.0	12.5	2.6	5.4	11.3	7.0
PP-19	3.78	2.52	14.2	2.21	--	--	3.78	0.63	0.63	2.52	1.26	12.3	4.4	14.8	7.8	16.0	3.5	6.3	14.2	7.0
PP-20	3.85	2.57	13.3	2.41	--	--	3.85	0.64	0.64	2.57	1.25	12.7	4.5	13.9	8.0	16.0	--	6.1	13.6	7.0
PP-21	3.86	2.57	14.5	2.25	--	--	3.86	0.64	0.64	2.57	1.29	12.5	4.5	15.1	8.1	15.0	3.0	5.5	9.5	7.0
PP-22	3.63	2.43	12.5	2.15	--	--	3.69	0.61	0.61	2.49	1.17	12.0	4.2	13.1	8.0	15.0	1.7	4.3	9.7	7.0
PP-23	3.78	2.61	15.2	2.45	--	--	3.81	0.64	0.64	2.51	1.21	12.6	4.5	15.8	8.0	15.3	1.9	4.5	8.8	7.0
Avg	**3.37**	**2.57**	**13.9**	**2.19**	**1.39**	**13.0**	**3.34**	**1.00**	**0.67**	**1.97**	**1.18**	**9.4**	**4.2**	**14.2**	**8.1**	**16.1**	**2.9**	**8.6**	**18.5**	**7.0**
Max	3.98	3.10	15.2	3.60	1.83	15.1	3.98	2.15	1.11	2.65	1.83	12.9	5.7	15.8	8.5	27.0	4.1	14.0	32.1	7.0
Min	0.31	2.17	11.2	1.55	1.18	10.8	1.26	0.61	0.61	0.83	0.84	4.1	3.3	11.5	7.8	10.0	1.7	4.3	8.8	7.0
%SD	31%	8%	8%	22%	17%	13%	23%	47%	19%	39%	23%	34%	15%	10%	2%	25%	28%	41%	41%	0%

Metallurgical Summary

Test	General Feed Conditions						Column	Column Concentrate			Mech. Concentrate			Tails	Combined Concentrate		
	% - 100 m	Dens % Sol	A350 g/t	DF250 g/t	P.Oil g/t	Assay % Cu	Feed kg/h	Mass Wt %	Assay % Cu	Rec'y Cu	Mass Wt %	Assay % Cu	Rec'y Cu	Assay % Cu	Mass Wt %	Assay % Cu	Rec'y Cu
PP-1	83.2	41	4.11	5.66	13.1	0.37	--	--	--	--	0.94	29.2	74.7	0.09	--	--	--
PP-2	65.4	41	4.82	4.95	15.2	0.36	--	--	--	--	1.05	23.2	67.2	0.12	--	--	--
PP-3	53.7	38	4.71	4.10	13.9	0.40	--	--	--	--	0.62	32.9	50.6	0.20	--	--	--
PP-4	57.3	41	5.90	3.48	15.0	0.35	--	--	--	--	0.66	37.6	70.5	0.10	--	--	--
PP-5	58.9	41	6.13	3.38	15.6	0.42	--	--	--	--	0.77	36.6	66.4	0.14	--	--	--
PP-6	55.5	40	6.42	3.36	15.8	0.34	--	--	--	--	0.61	34.3	61.5	0.13	--	--	--
PP-7	54.8	41	6.45	3.68	11.9	0.35	--	--	--	--	0.57	39.3	63.2	0.13	--	--	--
PP-8	59.9	38	9.16	3.34	11.9	0.35	--	--	--	--	0.64	37.7	70.1	0.10	--	--	--
PP-9	46.8	29	9.66	3.33	11.5	0.33	--	--	--	--	0.55	38.9	64.5	0.12	--	--	--
PP-11	57.1	19	8.07	4.03	11.8	0.41	305.3	0.12	41.4	12.1	0.53	41.9	54.2	0.19	0.65	41.8	66.3
PP-13	55.6	19	11.1	4.44	14.9	0.43	275.1	0.17	42.7	17.5	0.48	39.9	46.3	0.15	0.65	41.6	65.4
PP-14	57.4	18	11.1	4.44	14.9	0.40	297.9	0.13	51.1	16.8	0.75	23.8	45.2	0.15	0.88	25.4	56.6
PP-15	55.4	25	12.1	4.96	14.6	0.44	334.7	0.56	43.9	56.4	1.27	11.1	32.3	0.05	1.83	21.2	88.7
PP-16	54.5	26	12.4	4.46	15.0	0.33	329.4	0.16	47.2	23.0	0.40	32.9	39.5	0.12	0.56	37.0	62.5
PP-18	53.0	18	12.9	4.64	15.6	0.41	266.6	0.35	48.1	41.3	0.29	35.4	25.5	0.14	0.64	42.3	66.8
PP-19	60.1	21	12.3	4.41	14.8	0.32	312.7	0.20	43.2	26.8	0.35	34.2	37.4	0.12	0.55	37.5	64.2
PP-20	50.9	21	12.7	4.46	13.9	0.41	--	--	--	--	0.59	39.0	55.8	0.18	--	--	--
PP-21	51.8	20	12.5	4.50	15.1	0.35	348.7	0.24	48.1	32.7	0.37	37.8	39.4	0.10	0.61	41.9	72.1
PP-22	46.8	16	12.0	4.21	13.1	0.45	1,222	0.30	42.1	28.4	0.15	41.5	14.0	0.26	0.45	41.9	42.4
PP-23	47.6	16	12.6	4.45	15.8	0.46	828.2	0.40	41.3	36.2	0.29	38.7	24.6	0.18	0.69	40.2	60.8
Avg	**53.7**	**20**	**11.8**	**4.45**	**14.5**	**0.40**		**0.26**	**44.9**	**29.1**	**0.50**	**34.2**	**37.7**	**0.15**	**0.75**	**37.1**	**64.6**
Max	83.2	41	12.9	5.66	15.8	0.46		0.56	51.1	56.4	1.27	41.9	74.7	0.26	1.83	42.3	88.7
Min	46.8	16	4.1	3.33	11.5	0.32		0.12	41.3	12.1	0.15	11.1	14.0	0.05	0.45	21.2	42.4
%SD	15%	52%	27%	14%	10%	11%		53%	8%	45%	55%	22%	47%	31%	53%	20%	18%

Summary of Unit Performance

Test	Unit Column Cell			Rougher			Scavenger			Pre-Cleaner			Cleaner			Cleaner/Scavenger		
	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.	Grade % Cu	Rec'y O'All	Rec'y Indiv.
PP-1	--	--	--	6.60	75.5	54.3	2.88	38.2	60.2	31.1	72.2	93.7	10.5	2.50	52.0	1.81	1.5	65.8
PP-2	--	--	--	1.31	76.1	53.9	0.41	32.8	50.3	25.5	62.0	73.3	11.3	5.20	23.0	2.47	8.6	49.2
PP-3	--	--	--	7.34	51.8	40.9	12.2	25.3	33.8	38.1	48.0	92.3	9.00	2.50	63.4	4.31	0.2	14.8
PP-4	--	--	--	7.29	74.2	48.7	2.07	49.7	62.9	38.3	64.4	86.2	31.5	6.10	60.6	15.8	1.4	33.9
PP-5	--	--	--	3.44	69.8	55.3	1.26	23.0	40.7	39.8	50.4	72.4	29.3	16.0	61.0	1.30	0.8	19.3
PP-6	--	--	--	3.51	68.7	40.9	1.05	59.8	60.6	37.1	49.4	67.1	26.4	12.1	55.8	23.4	1.9	19.2
PP-7	--	--	--	18.0	64.0	47.9	4.99	33.0	47.3	40.0	60.7	93.7	26.3	2.40	55.7	6.74	0.7	45.0
PP-8	--	--	--	20.1	69.8	53.3	6.99	30.3	50.2	38.0	67.7	94.5	29.3	2.30	57.7	7.50	0.9	52.7
PP-9	--	--	--	11.2	69.1	39.2	2.64	70.6	66.0	39.1	59.1	80.8	36.9	5.40	38.1	2.79	4.1	47.3
PP-11	41.4	12.1	8.8	23.5	56.0	44.0	4.92	25.5	35.8	42.8	51.1	86.2	31.1	3.1	38.6	2.81	3.3	65.7
PP-13	42.7	17.5	14.0	22.6	47.4	42.3	2.57	28.8	44.4	40.6	44.5	93.7	28.2	2.0	64.8	19.20	0.1	4.2
PP-14	51.1	16.8	12.5	20.8	45.4	35.1	5.20	46.6	55.3	23.8	44.6	96.1	27.0	0.6	33.4	2.81	0.9	73.2
PP-15	43.9	56.4	41.7	5.10	32.7	51.8	3.55	17.7	60.9	11.1	32.3	93.5	12.1	0.1	1.3	3.23	0.3	12.3
PP-16	47.2	23.0	15.4	25.9	39.7	35.6	4.67	34.2	47.6	32.9	39.1	98.2	30.6	0.4	52.4	11.3	0.1	11.1
PP-18	48.1	41.3	33.1	15.2	26.4	28.0	3.44	34.9	51.4	35.5	24.3	87.5	33.4	1.2	35.1	4.91	1.4	57.5
PP-19	43.2	26.8	20.0	22.8	38.0	40.9	2.04	19.0	34.6	34.3	37.3	98.2	24.0	0.1	10.5	12.3	0.1	12.0
PP-20	--	--	--	16.2	58.5	44.2	2.02	29.7	40.2	39.7	53.1	87.7	28.3	2.7	36.2	10.4	2.0	42.7
PP-21	48.1	32.7	25.3	37.8	39.4	58.6	1.53	62.8	69.3	38.1	38.6	93.6	29.1	0.9	33.5	11.3	0.7	37.1
PP-22	42.1	28.4	11.7	24.9	14.1	12.4	3.92	41.9	42.1	41.9	13.5	94.7	32.2	0.4	57.6	9.50	0.2	49.9
PP-23	41.3	36.2	16.2	10.4	26.3	37.4	2.04	4.90	11.2	39.5	23.4	79.3	27.6	1.2	19.9	8.36	3.2	66.2
Avg	**44.9**	**29.1**	**19.9**	**20.5**	**38.5**	**39.1**	**3.26**	**31.5**	**44.8**	**34.6**	**36.5**	**91.7**	**27.6**	**1.2**	**34.8**	**8.73**	**1.1**	**39.3**
Max	51.1	56.4	41.7	37.8	76.1	58.6	12.2	70.6	69.3	42.8	72.2	98.2	36.9	16.0	64.8	23.4	8.6	73.2
Min	41.3	12.1	8.8	1.3	14.1	12.4	0.41	4.9	11.2	11.1	13.5	67.1	9.0	0.1	1.3	1.30	0.1	4.2
%SD	8%	45%	53%	47%	49%	28%	80%	51%	31%	22%	43%	10%	30%	355%	53%	70%	180%	56%

Summary of Column Flotation

Test	Feed Conditions						Operating Conditions						Tails			Concentrate			
	CLR %	Solids tph	Pulp L/min	Grade %Cu	Mesh %-100	K80 µm	Level cm	NRT min	Holdup %	Bias cm/sec	Conc kg/h	Loading g/min/cm2	Pulp L/min	Density		Mesh %-100	K80 µm	Grade %Cu	Recov Cu%
														g/L	%Sol				
PP-13	45%	275.1	14.0	0.36	39.3	595	26.0	2.99	17.5	0.13	0.32	0.030	12.7	1,240	30.4	95.2	74	42.7	17.5
PP-14	57%	297.9	14.3	0.34	35.2	831	32.2	2.85	13.0	0.13	0.25	0.023	12.9	1,160	21.7	98.3	70	51.1	16.8
PP-15	73%	334.7	10.8	0.34	31.4	851	34.4	3.87	22.1	0.13	1.08	0.102	9.4	1,308	37.0	92.6	97	43.9	56.4
PP-16	75%	329.4	11.0	0.28	29.7	849	32.2	3.79	24.4	0.12	0.30	0.028	9.7	1,324	38.5	96.8	78	47.2	23.0
PP-18	48%	266.6	13.1	0.35	35.6	792	29.6	3.17	17.5	0.13	0.63	0.060	11.8	1,166	22.4	98.5	70	48.1	41.3
PP-19	64%	312.7	11.7	0.26	34.7	880	29.6	3.29	28.0	0.03	0.38	0.036	11.4	1,290	35.3	97.3	80	43.2	26.8
PP-21	87%	348.7	14.9	0.24	18.0	1,200	14.0	2.96	24.6	0.13	0.45	0.042	13.5	1,280	34.4	97.9	71	48.1	32.7
PP-22	526%	1,221.9	24.5	0.17	9.7	1,343	30.0	1.60	40.3	0.11	0.59	0.055	23.3	1,555	56.1	95.4	70	42.1	28.4
PP-23	339%	828.2	15.2	0.23	11.5	1,368	29.0	2.65	35.0	0.11	0.75	0.071	14.1	1,403	45.1	96.4	81	41.3	36.2
Avg	146%	468.4	14.4	0.29	27.2	968	28.6	3.02	24.7	0.11	0.53	0.050	13.2	1,303	35.7	96.5	77	45.3	31.0
Max	526%	1,221.9	24.5	0.36	39.3	1,368	34.4	3.87	40.3	0.13	1.08	0.102	23.3	1,555	56.1	98.5	97	51.1	56.4
Min	45%	266.6	10.8	0.17	9.7	595	14.0	1.60	13.0	0.03	0.25	0.023	9.4	1,160	21.7	92.6	70	41.3	16.8
%SD	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%

1. **Purpose:** To fill up the flotation circuit and ensure that all pumps and pipe lines are sized correctly and operating properly, and to evaluate the grinding circuit with respect to product size and load distribution between the rod mill and ball mill.

2. **Procedure:** The Sweco primary screen deck was coarsened from 80 mesh (178 µm) to 60 mesh (310 µm).
The circuit was started at 9:20 AM and sampled from 2:00 to 4:00 PM, with shutdown at 4:00 PM. No significant problems were experienced in the run.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	83.2 % -100 mesh
Copper Head Grade	0.37 % Cu
Final Tails Grade	0.09 % Cu
Final Copper Grade	29.2 % Cu
Final Copper Recovery	74.7 %

Flotation feed (screen undersize) was too fine at 83.2% -100 mesh, compared to the target of about 65% -100 mesh. Reagent levels were inadequate for the finer grind, and copper recovery was accordingly low at 75%. The pre-cleaner pulled a fairly good grade (31.7% Cu) for a first day's run, but recovery was too high, leaving very little for the cleaner to work with. Striking a balance between pre-cleaner and cleaner will probably be a key operational control point for this project. Problems with excessive agitator speed in the scavenger bank of cells resulted in very poor performance in the scavenger.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	194.8 kg/h	-1/4 inch	(Wet Sple 804.4 g) (Dry Sple 783.9 g)
Feed Rate:	189.8 kg/h	dry ore	(Moisture 2.55 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	200 kg		
Rod Mill Feed:	Total	1,299 kg in 6.67 hr	
	Sample	390 kg in 2.00 hr	
Rod Mill Discharge:	1,606 g/L		(59 % Sol at SG 2.75)
	39.7	% plus 48 mesh	
	38.2	% minus 100 mesh	
Input Power:	34.81	for 3 disc revolutions	
	1.12	kW	(95% drive efficiency)
Average Power:	1.06 kW	Gross	
	0.47 kW	No Load	
	0.59 kW	Net	
Net Power Usage:	3.09 kWh/t	of -1/4 inch feed	
K80 Feed:	4,093	microns	
K80 Product:	492	microns	
Work Index (metric):	10.5		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 166 % circ. load)
Feed Rate:	314.4 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	200 kg		
Screen Undersize:	1,350 g/L		(41 % Sol at SG 2.75)
Ball Mill Discharge:	1,642 g/L		(61 % Sol at SG 2.75)
	5.4	% plus 48 mesh	
	65.6	% minus 100 mesh	
Input Power:	29.50	for 3 disc revolutions	
	1.32	kW	(95% drive efficiency)
Average Power:	1.25 kW	Gross	
	0.52 kW	No Load	
	0.73 kW	Net	
Net Power Usage:	2.32 kWh/t	of screen oversize	
K80 Feed:	492	microns	
K80 Product:	137	microns	
Work Index (metric):	5.7		

3.1.3. Overall Mill Report:

Net Power Usage:	5.41 kWh/t
K80 Feed:	4,093 microns
K80 Product:	137 microns
Work Index (metric):	7.8
Screen Undersize:	83.2 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,093	15.2
Rod Mill Discharge	492	38.2
Screen Feed	308	54.3
Ball Mill Feed	408	29.9
Ball Mill Discharge	195	65.6
Screen Undersize	137	83.2
Rougher Feed	126	87.1
Regrind Feed	38.0	99.8
Regrind Discharge	35.0	99.9
Final Concentrate	67.3	98.1
Final Tail	134	84.3

3.2. Reagent Additions:

Average Feed Rate: 0.190 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	PAX	0.10%	6.1	1.93
	DF-250	0.10%	5.8	1.83
	Pine Oil	100%	4.2 dr	11.95
Scavenger Feed	PAX	0.10%	4.0	1.26
	DF-250	0.10%	6.8	2.15
	Pine Oil	0.10%	3.5	1.11
Scavenger Cell 4	PAX	0.10%	2.9	0.92
	DF-250	0.10%	5.3	1.68
Total	**PAX**			**4.11**
	DF-250			**5.66**
	Pine Oil			**13.05**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)
Rod Mill Discharge	1,606		
Ball Mill Discharge	1,642		
Screen Undersize	1,350		
Rougher Feed		8.17	
Pre-Cleaner Feed		8.16	
Cleaner Feed		8.24	
Scavenger Tail	1,450		

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	205.2	1,350	6.2	13.5
Scavenger	168	197.3	1,400	5.2	32.1
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results: (166% circulating load)

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

	Direct Assays		Adjusted Assays		Mass Flow
Product	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.38	1.20	0.37	1.23	189.8
Rod Mill Discharge			0.37	1.23	189.8
Ball Mill Discharge	0.23	0.94	0.25	0.97	314.4
Screen Feed	0.32	1.10	0.30	1.06	504.2
Screen Oversize	0.26	0.95	0.25	0.97	314.4
Screen Undersize	0.35	1.24	0.37	1.23	189.8
Rougher Feed	0.42	1.47	0.47	1.34	205.2
Rougher Conc	6.61	4.78	6.60	4.91	7.97
Rougher Tail	0.23	1.37	0.22	1.19	197.3
Scav Tail (final)	0.094	1.28	0.09	1.10	188.0
Scavenger Conc	2.96	2.97	2.88	3.11	9.24
Pre-Cleaner Feed	6.12	4.53	6.27	4.84	8.55
Pre-Cleaner Conc	30.4	15.6	31.1	15.6	1.62
Pre-Cleaner Tail	0.55	2.16	0.49	2.33	6.94
Cleaner Feed	0.51	2.46	0.49	2.33	6.94
Cleaner Conc	10.40	6.84	10.5	6.78	0.17
Cleaner Tail	0.17	2.27	0.24	2.22	6.77
Clnr-Scav Conc	1.97	3.72	1.81	3.87	0.59
Clnr-Scav Tail	0.10	2.17	0.09	2.06	6.19
Final Concentrate	29.2	14.9	29.2	14.8	1.78

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.00	0.37	1.23	100.0	100.0
Final Conc	0.94	29.2	14.8	74.7	11.3
Final Tail	99.06	0.094	1.10	25.3	88.7
Rougher Feed	108.13	0.47	1.34	139.1	117.8
Conc	4.20	6.60	4.91	75.5	16.8
Tail	103.93	0.22	1.19	63.6	101.0
Scavenger Feed	103.93	0.22	1.19	63.4	101.0
Conc	4.87	2.88	3.11	38.2	12.4
Tail	99.06	0.094	1.10	25.3	88.6
Combined Clnr Feed	4.20	6.60	4.91	75.5	16.8
Final Conc	0.94	29.2	14.8	74.7	11.3
Clnr/Scav Tail	3.26	0.09	2.06	0.8	5.5
Pre-Cleaner Feed	4.51	6.27	4.84	77.0	17.8
Conc	0.85	31.1	15.6	72.2	10.9
Tail	3.66	0.49	2.33	4.8	6.9
Cleaner Feed	3.66	0.49	2.33	4.8	6.9
Conc	0.09	10.5	6.78	2.5	0.5
Tail	3.57	0.24	2.22	2.3	6.5
Clnr/Scav Feed	3.57	0.24	2.22	2.3	6.5
Conc	0.31	1.81	3.87	1.5	1.0
Tail	3.26	0.09	2.06	0.8	5.5
Cleaners Only Feed	4.51	6.27	4.84	77.0	17.8
Final Conc	0.94	29.2	14.8	74.7	11.3
Cleaner Tail	3.57	0.24	2.22	2.3	6.5

4.3. Individual Unit Performance:

Product	Overall	Assays		Distributions (%)	
	Wt %	Cu	Fe	Cu	Fe
New Feed	100.0	0.37	1.23	100.0	100.0
Final Conc	0.94	29.2	14.8	74.7	11.3
Final Tail	99.1	0.094	1.10	25.3	88.7
Rougher Feed	100.0	0.47	1.34	100.0	100.0
Conc	3.9	6.60	4.91	54.3	14.3
Tail	96.1	0.22	1.19	45.7	85.7
Scavenger Feed	100.0	0.22	1.19	100.0	100.0
Conc	4.7	2.88	3.11	60.2	12.2
Tail	95.3	0.094	1.10	39.8	87.8
*** Combined Clnr Feed	100.0	6.60	4.91	100.0	100.0
Final Conc	22.4	29.2	14.8	98.9	67.4
Clnr/Scav Tail	77.6	0.090	2.060	1.1	32.6
Pre-Cleaner Feed	100.0	6.27	4.84	100.0	100.0
Conc	18.9	31.1	15.6	93.7	61.0
Tail	81.1	0.49	2.33	6.3	39.0
Cleaner Feed	100.0	0.49	2.33	100.0	100.0
Conc	2.41	10.5	6.78	52.0	7.0
Tail	97.6	0.24	2.22	48.0	93.0
Clnr/Scav Feed	100.0	0.24	2.22	100.0	100.0
Conc	8.66	1.81	3.87	65.8	15.1
Tail	91.3	0.09	2.06	34.2	84.9
Cleaners Only Feed	100.0	6.27	4.84	100.0	100.0
Final Conc	20.8	29.2	14.8	97.0	63.7
Cleaner Tail	79.2	0.24	2.22	3.0	36.3

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	51.0	12.7	12.7	87.3
6	3,327	66.3	16.5	29.2	70.8
8	2,362	46.5	11.6	40.8	59.2
10	1,651	44.1	11.0	51.8	48.2
14	1,168	33.1	8.3	60.1	39.9
20	833	23.7	5.9	66.0	34.0
28	589	20.5	5.1	71.1	28.9
35	417	17.4	4.3	75.4	24.6
48	295	13.6	3.4	78.8	21.2
65	208	12.2	3.0	81.9	18.1
100	147	11.9	3.0	84.8	15.2
150	104	10.4	2.6	87.4	12.6
200	74	9.3	2.3	89.8	10.2
270	53	8.3	2.1	91.8	8.2
400	37	5.4	1.3	93.2	6.8
Pan	-37	27.4	6.8	100.0	0.0
Total	-	**401.1**	**100.0**	-	-
K80	**4,093**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.8	0.5	0.5	99.5
20	833	4.7	3.0	3.5	96.5
28	589	14.0	8.9	12.5	87.5
35	417	22.3	14.2	26.7	73.3
48	295	20.3	13.0	39.7	60.3
65	208	19.2	12.3	51.9	48.1
100	147	15.5	9.9	61.8	38.2
150	104	11.2	7.2	69.0	31.0
200	74	9.0	5.7	74.7	25.3
270	53	7.0	4.5	79.2	20.8
400	37	4.7	3.0	82.2	17.8
Pan	-37	27.9	17.8	100.0	0.0
Total	-	**156.6**	**100.0**	-	-
K80	**492**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.3	0.2	0.2	99.8
20	833	2.0	1.3	1.5	98.5
28	589	5.8	3.7	5.2	94.8
35	417	11.4	7.3	12.5	87.5
48	295	13.0	8.3	20.8	79.2
65	208	17.7	11.4	32.2	67.8
100	147	21.1	13.5	45.7	54.3
150	104	19.4	12.4	58.2	41.8
200	74	15.2	9.7	67.9	32.1
270	53	10.9	7.0	74.9	25.1
400	37	7.1	4.6	79.5	20.5
Pan	-37	32.0	20.5	100.0	0.0
Total	-	**155.9**	**100.0**	-	-
K80	**308**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.7	0.3	0.3	99.7
20	833	3.7	1.6	1.9	98.1
28	589	13.5	5.7	7.6	92.4
35	417	28.1	11.9	19.4	80.6
48	295	33.9	14.3	33.7	66.3
65	208	45.1	19.0	52.8	47.2
100	147	41.1	17.3	70.1	29.9
150	104	25.7	10.8	81.0	19.0
200	74	16.0	6.8	87.7	12.3
270	53	9.8	4.1	91.9	8.1
400	37	5.0	2.1	94.0	6.0
Pan	-37	14.3	6.0	100.0	0.0
Total	-	**236.9**	**100.0**	-	-
K80	**408**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.0	0.0	0.0	100.0
20	833	0.0	0.0	0.0	100.0
28	589	0.0	0.0	0.0	100.0
35	417	1.5	1.2	1.2	98.8
48	295	5.2	4.2	5.4	94.6
65	208	13.6	10.9	16.3	83.7
100	147	22.5	18.1	34.4	65.6
150	104	21.5	17.3	51.7	48.3
200	74	16.7	13.4	65.1	34.9
270	53	11.3	9.1	74.2	25.8
400	37	6.8	5.5	79.7	20.3
Pan	-37	25.3	20.3	100.0	0.0
Total	-	124.4	100.0	-	-
K80	195				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	4.8	4.1	4.1	95.9
100	147	14.8	12.7	16.8	83.2
150	104	17.8	15.3	32.1	67.9
200	74	17.0	14.6	46.7	53.3
270	53	14.0	12.0	58.7	41.3
400	37	10.2	8.7	67.4	32.6
Pan	-37	38.0	32.6	100.0	0.0
Total	-	116.6	100.0	-	-
K80	137				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	4.1	2.6	2.6	97.4
100	147	16.2	10.3	12.9	87.1
150	104	23.2	14.8	27.7	72.3
200	74	22.0	14.0	41.8	58.2
270	53	18.0	11.5	53.3	46.7
400	37	14.4	9.2	62.4	37.6
Pan	-37	58.9	37.6	100.0	0.0
Total	-	**156.8**	**100.0**	-	-
K80	**126**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.2	0.2	0.2	99.8
150	104	1.5	1.2	1.4	98.6
200	74	4.1	3.4	4.8	95.2
270	53	8.8	7.2	12.0	88.0
400	37	10.5	8.6	20.7	79.3
Pan	-37	96.3	79.3	100.0	0.0
Total	-	**121.4**	**100.0**	-	-
K80	**38.0**				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.1	0.1	0.1	99.9
150	104	1.2	0.9	0.9	99.1
200	74	3.1	2.2	3.2	96.8
270	53	7.9	5.7	8.9	91.1
400	37	10.8	7.8	16.7	83.3
Pan	-37	115.5	83.3	100.0	0.0
Total	-	**138.6**	**100.0**	-	-
K80	**35.0**				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	2.5	1.9	1.9	98.1
150	104	7.9	5.9	7.8	92.2
200	74	11.5	8.6	16.4	83.6
270	53	16.1	12.1	28.5	71.5
400	37	15.4	11.6	40.1	59.9
Pan	-37	79.9	59.9	100.0	0.0
Total	-	133.3	100.0	-	-
K80	67.3				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	5.0	3.4	3.4	96.6
100	147	18.1	12.3	15.7	84.3
150	104	22.9	15.5	31.2	68.8
200	74	21.3	14.5	45.7	54.3
270	53	17.1	11.6	57.3	42.7
400	37	10.7	7.3	64.5	35.5
Pan	-37	52.3	35.5	100.0	0.0
Total	-	147.4	100.0	-	-
K80	134				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 167.6 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	0.0	0.0	0.0	0.0	0.0
14	0.5	0.0	0.3	0.0	0.2
20	3.0	0.0	1.6	0.0	1.3
28	8.9	0.0	5.7	0.0	3.7
35	14.2	0.0	11.9	1.2	7.3
48	13.0	0.0	14.3	4.2	8.3
65	12.3	4.1	19.0	10.9	11.4
100	9.9	12.7	17.3	18.1	13.5
150	7.2	15.3	10.8	17.3	12.4
200	5.7	14.6	6.8	13.4	9.7
270	4.5	12.0	4.1	9.1	7.0
400	3.0	8.7	2.1	5.5	4.6
Pan	17.8	32.6	6.0	20.3	20.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	0.0	0.0
14	173 %	0.2	0.3
20	192 %	1.0	2.0
28	157 %	3.5	5.5
35	134 %	6.8	9.1
48	128 %	8.0	10.3
65	100 %	11.6	11.7
100	379 %	16.4	62.0
150	126 %	12.8	16.1
200	132 %	10.1	13.4
270	152 %	7.3	11.1
400	171 %	4.6	7.8
Pan	103 %	17.8	18.4
Total	**--**	**100.0**	**167.6 %**

1. **Purpose:** To refine the distribution of grinding energy between the rod and ball mills, and to coarsen the flotation feed.

2. **Procedure:** The Sweco primary screen deck was coarsened from 60 mesh (310 μm) to 24 mesh (703 μm). The rod mill charge was reduced by 50 kg, and the ball charge was also reduced by 50 kg. The scavenger cell impellor drive sheaves were adjusted to reduce impellor speed from about 85 RPM to about 57 RPM. Collector levels remained unchanged, but frother levels were reduced by about 25% in response to the coarser feed grind.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	65.4 % -100 mesh
Copper Head Grade	0.36 % Cu
Final Tails Grade	0.12 % Cu
Final Copper Grade	23.2 % Cu
Final Copper Recovery	67.2 %

The coarser screen shifted the grinding load to the ball mill, but resulted in a flotation feed size that, at 65.4% -100 mesh, was very close to target. The frother levels were too high, and this resulted in excessive froth production. The problem was corrected just at the start of the sample period, and the improvement did not become apparent until near the end of the sample period. Concentrate grades were low throughout the circuit, starting with the rougher. The balance between pre-cleaner and cleaner improved significantly near the end of the sampling run and should be evident in the next run.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	194.9 kg/h	-1/4 inch	(Wet Sple 774.6 g)
			(Dry Sple 756.9 g)
Feed Rate:	190.4 kg/h	dry ore	(Moisture 2.29 %)
Mill Speed:	45 RPM	(85% of critical speed)	
Rod Load:	150 kg		
Rod Mill Feed:	Total	975 kg in 5.00 hr	
	Sample	390 kg in 2.00 hr	
Rod Mill Discharge:	1,585 g/L	(58 % Sol at SG 2.75)	
	46.6	% plus 48 mesh	
	34.2	% minus 100 mesh	
Input Power:	38.65	for 3 disc revolutions	
	1.01	kW (95% drive efficiency)	
Average Power:	0.96 kW	Gross	
	0.47 kW	No Load	
	0.48 kW	Net	
Net Power Usage:	2.53 kWh/t	of -1/4 inch feed	
K80 Feed:	4,033	microns	
K80 Product:	607	microns	
Work Index (metric):	10.2		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 179 % circ. load)
Feed Rate:	340.4 kg/h		
Mill Speed:	40 RPM	(77% of critical speed)	
Ball Load:	150 kg		
Screen Undersize:	1,350 g/L	(41 % Sol at SG 2.75)	
Ball Mill Discharge:	1,658 g/L	(62 % Sol at SG 2.75)	
	5.6	% plus 48 mesh	
	79.4	% minus 100 mesh	
Input Power:	35.00	for 3 disc revolutions	
	1.11	kW (95% drive efficiency)	
Average Power:	1.06 kW	Gross	
	0.52 kW	No Load	
	0.53 kW	Net	
Net Power Usage:	1.56 kWh/t	of screen oversize	
K80 Feed:	607	microns	
K80 Product:	243	microns	
Work Index (metric):	6.6		

3.1.3. Overall Mill Report:

Net Power Usage:	4.09 kWh/t
K80 Feed:	4,033 microns
K80 Product:	243 microns
Work Index (metric):	8.5
Screen Undersize:	83.2 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,033	13.9
Rod Mill Discharge	607	34.6
Screen Feed	475	49.4
Ball Mill Feed	818	10.5
Ball Mill Discharge	152	79.4
Screen Undersize	243	65.4
Rougher Feed	202	71.5
Regrind Feed	51.3	97.4
Regrind Discharge	35.0	97.6
Final Concentrate	62.6	96.9
Final Tail	261	61.6

3.2. Reagent Additions:

Average Feed Rate: 0.190 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	PAX	0.10%	6.4	2.02
	DF-250	0.10%	3.8	1.20
	Pine Oil	100%	5.0 dr	14.18
Scavenger Feed	PAX	0.10%	5.9	1.86
	DF-250	0.10%	6.1	1.92
	Pine Oil	0.10%	3.1	0.98
Scavenger Cell 4	PAX	0.10%	3.0	0.95
	DF-250	0.10%	5.8	1.83
Total	**PAX**			**4.82**
	DF-250			**4.95**
	Pine Oil			**15.15**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,585			2.75
Ball Mill Discharge	1,658			
Screen Undersize	1,350			
Rougher Feed		8.17	21	
Pre-Cleaner Feed		8.17		
Cleaner Feed		8.16		
Scavenger Tail	1,438			
Final Concentrate				3.44

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	283.6	1,350	8.6	9.8
Scavenger	168	243.3	1,394	6.5	25.7
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results: (179% circulating load)

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.41	1.60	0.36	1.52	190.4
Rod Mill Discharge			0.36	1.52	190.4
Ball Mill Discharge	0.25	1.28	0.29	1.28	340.4
Screen Feed	0.49	1.62	0.31	1.37	530.9
Screen Oversize	0.26	1.09	0.29	1.28	340.4
Screen Undersize	0.33	1.44	0.36	1.52	190.4
Rougher Feed	0.34	2.06	0.34	1.75	283.6
Rougher Conc	1.28	2.75	1.31	2.91	40.27
Rougher Tail	0.18	1.46	0.19	1.56	243.3
Scav Tail (final)	0.120	1.50	0.12	1.40	188.4
Scavenger Conc	0.27	2.13	0.41	2.09	54.84
Pre-Cleaner Feed	1.79	3.02	1.37	2.96	42.67
Pre-Cleaner Conc	30.6	16.0	25.5	13.9	1.68
Pre-Cleaner Tail	0.63	2.51	0.38	2.51	40.99
Cleaner Feed	0.68	2.64	0.38	2.51	40.99
Cleaner Conc	11.00	7.57	11.3	7.47	0.32
Cleaner Tail	0.28	2.39	0.30	2.47	40.67
Clnr-Scav Conc	2.32	3.75	2.47	3.71	2.40
Clnr-Scav Tail	0.16	2.40	0.16	2.39	38.27
Final Concentrate	23.2	12.9	23.2	12.9	2.00

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.00	0.36	1.52	100.0	100.0
Final Conc	1.05	23.2	12.9	67.2	8.9
Final Tail	98.95	0.12	1.40	32.8	91.1
Rougher Feed	148.89	0.34	1.75	141.1	171.1
Conc	21.15	1.31	2.91	76.1	40.4
Tail	127.75	0.19	1.56	65.0	130.7
Scavenger Feed	127.75	0.19	1.56	65.1	130.7
Conc	28.80	0.41	2.09	32.8	39.5
Tail	98.95	0.120	1.40	32.3	91.2
Combined Clnr Feed	21.15	1.31	2.91	76.1	40.4
Final Conc	1.05	23.2	12.9	67.2	8.9
Clnr/Scav Tail	20.10	0.16	2.39	8.8	31.6
Pre-Cleaner Feed	22.41	1.37	2.96	84.7	43.5
Conc	0.88	25.5	13.9	62.0	8.0
Tail	21.52	0.38	2.51	22.6	35.5
Cleaner Feed	21.52	0.38	2.51	22.7	35.4
Conc	0.17	11.3	7.47	5.2	0.8
Tail	21.36	0.30	2.47	17.5	34.6
Clnr/Scav Feed	21.36	0.30	2.47	17.5	34.6
Conc	1.26	2.47	3.71	8.6	3.1
Tail	20.10	0.16	2.39	8.9	31.6
Cleaners Only Feed	22.41	1.37	2.96	84.7	43.5
Final Conc	1.05	23.2	12.9	67.2	8.9
Cleaner Tail	21.36	0.30	2.47	17.4	34.6

4.3. Individual Unit Performance:

	Overall	Assays		Distributions (%)	
Product	Wt %	Cu	Fe	Cu	Fe
New Feed	100.0	0.36	1.52	100.0	100.0
Final Conc	1.05	23.2	12.9	67.2	8.9
Final Tail	99.0	0.120	1.40	32.8	91.1
Rougher Feed	100.0	0.34	1.75	100.0	100.0
Conc	14.2	1.31	2.91	53.9	23.6
Tail	85.8	0.19	1.56	46.1	76.4
Scavenger Feed	100.0	0.19	1.56	100.0	100.0
Conc	22.5	0.41	2.09	50.3	30.2
Tail	77.5	0.120	1.40	49.7	69.8
Combined Clnr Feed	100.0	1.31	2.91	100.0	100.0
Final Conc	5.0	23.2	12.9	88.4	21.9
Clnr/Scav Tail	95.0	0.160	2.394	11.6	78.1
Pre-Cleaner Feed	100.0	1.37	2.96	100.0	100.0
Conc	3.9	25.5	13.9	73.3	18.5
Tail	96.1	0.38	2.51	26.7	81.5
Cleaner Feed	100.0	0.38	2.51	100.0	100.0
Conc	0.78	11.3	7.47	23.0	2.3
Tail	99.2	0.30	2.47	77.0	97.7
Clnr/Scav Feed	100.0	0.30	2.47	100.0	100.0
Conc	5.91	2.47	3.71	49.2	8.9
Tail	94.1	0.16	2.39	50.8	91.1
Cleaners Only Feed	100.0	1.37	2.96	100.0	100.0
Final Conc	4.7	23.2	12.9	79.4	20.4
Cleaner Tail	95.3	0.30	2.47	20.6	79.6

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	53.9	11.9	11.9	88.1
6	3,327	75.3	16.6	28.5	71.5
8	2,362	55.0	12.1	40.6	59.4
10	1,651	49.0	10.8	51.4	48.6
14	1,168	39.9	8.8	60.2	39.8
20	833	28.3	6.2	66.5	33.5
28	589	24.3	5.4	71.8	28.2
35	417	20.3	4.5	76.3	23.7
48	295	15.6	3.4	79.7	20.3
65	208	15.5	3.4	83.2	16.8
100	147	13.2	2.9	86.1	13.9
150	104	11.1	2.4	88.5	11.5
200	74	10.5	2.3	90.8	9.2
270	53	9.5	2.1	92.9	7.1
400	37	6.8	1.5	94.4	5.6
Pan	-37	25.3	5.6	100.0	0.0
Total	-	**453.5**	**100.0**	-	-
K80	**4,033**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.4	0.3	0.3	99.7
14	1,168	2.3	1.5	1.8	98.2
20	833	8.9	5.9	7.7	92.3
28	589	19.1	12.7	20.4	79.6
35	417	22.3	14.8	35.2	64.8
48	295	17.3	11.5	46.6	53.4
65	208	14.9	9.9	56.5	43.5
100	147	13.3	8.8	65.4	34.6
150	104	10.2	6.8	72.1	27.9
200	74	8.2	5.4	77.6	22.4
270	53	6.7	4.4	82.0	18.0
400	37	3.7	2.5	84.5	15.5
Pan	-37	23.3	15.5	100.0	0.0
Total	-	**150.6**	**100.0**	-	-
K80	**607**				

Test No. PP-2

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	1.3	1.1	1.1	98.9
20	833	4.3	3.6	4.7	95.3
28	589	9.9	8.3	13.0	87.0
35	417	13.1	11.0	23.9	76.1
48	295	10.7	8.9	32.9	67.1
65	208	9.8	8.2	41.1	58.9
100	147	11.4	9.5	50.6	49.4
150	104	10.2	8.5	59.1	40.9
200	74	9.6	8.0	67.1	32.9
270	53	8.4	7.0	74.2	25.8
400	37	6.4	5.4	79.5	20.5
Pan	-37	24.5	20.5	100.0	0.0
Total	-	**119.6**	**100.0**	-	-
K80	**475**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.4	0.7	0.7	99.3
14	1,168	13.0	4.0	4.7	95.3
20	833	44.5	13.6	18.3	81.7
28	589	97.7	29.8	48.1	51.9
35	417	78.5	23.9	72.0	28.0
48	295	31.2	9.5	81.5	18.5
65	208	16.8	5.1	86.6	13.4
100	147	9.5	2.9	89.5	10.5
150	104	6.3	1.9	91.5	8.5
200	74	4.9	1.5	93.0	7.0
270	53	4.3	1.3	94.3	5.7
400	37	3.4	1.0	95.3	4.7
Pan	-37	15.4	4.7	100.0	0.0
Total	-	**327.9**	**100.0**	-	-
K80	**818**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	3.1	2.7	2.7	97.3
48	295	3.2	2.8	5.6	94.4
65	208	5.7	5.0	10.6	89.4
100	147	11.4	10.1	20.6	79.4
150	104	14.7	13.0	33.6	66.4
200	74	15.8	13.9	47.5	52.5
270	53	13.8	12.2	59.7	40.3
400	37	10.1	8.9	68.6	31.4
Pan	-37	35.6	31.4	100.0	0.0
Total	-	**113.4**	**100.0**	-	-
K80	152				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	2.8	2.6	2.6	97.4
35	417	6.9	6.4	9.0	91.0
48	295	7.4	6.8	15.8	84.2
65	208	7.9	7.3	23.1	76.9
100	147	12.5	11.5	34.6	65.4
150	104	12.1	11.2	45.8	54.2
200	74	11.5	10.6	56.4	43.6
270	53	10.1	9.3	65.7	34.3
400	37	7.0	6.5	72.2	27.8
Pan	-37	30.1	27.8	100.0	0.0
Total	-	**108.3**	**100.0**	-	-
K80	243				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	7.6	5.7	5.7	94.3
48	295	7.7	5.8	11.6	88.4
65	208	10.1	7.6	19.2	80.8
100	147	12.4	9.4	28.5	71.5
150	104	11.9	9.0	37.5	62.5
200	74	12.2	9.2	46.8	53.2
270	53	12.5	9.4	56.2	43.8
400	37	10.1	7.6	63.8	36.2
Pan	-37	47.9	36.2	100.0	0.0
Total	-	**132.4**	**100.0**	-	-
K80	**202**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.5	1.4	1.4	98.6
100	147	1.2	1.1	2.6	97.4
150	104	2.7	2.6	5.1	94.9
200	74	5.6	5.3	10.4	89.6
270	53	9.3	8.8	19.3	80.7
400	37	8.2	7.8	27.1	72.9
Pan	-37	76.8	72.9	100.0	0.0
Total	-	**105.3**	**100.0**	-	-
K80	**51.3**				

Test No. PP-2

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.2	1.1	1.1	98.9
100	147	1.4	1.3	2.4	97.6
150	104	2.7	2.5	4.8	95.2
200	74	5.5	5.0	9.8	90.2
270	53	8.9	8.1	17.9	82.1
400	37	8.7	7.9	25.8	74.2
Pan	-37	81.6	74.2	100.0	0.0
Total	-	**110.0**	**100.0**	-	-
K80	**35.0**				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.6	0.8	0.8	99.2
100	147	1.8	2.3	3.1	96.9
150	104	3.7	4.8	7.9	92.1
200	74	5.6	7.2	15.1	84.9
270	53	7.0	9.0	24.1	75.9
400	37	5.7	7.3	31.4	68.6
Pan	-37	53.2	68.6	100.0	0.0
Total	-	**77.6**	**100.0**	-	-
K80	**62.6**				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.9	0.5	0.5	99.5
35	417	12.3	7.3	7.9	92.1
48	295	15.0	8.9	16.8	83.2
65	208	15.5	9.2	26.1	73.9
100	147	20.7	12.3	38.4	61.6
150	104	18.9	11.3	49.7	50.3
200	74	17.3	10.3	60.0	40.0
270	53	14.9	8.9	68.9	31.1
400	37	9.7	5.8	74.7	25.3
Pan	-37	42.5	25.3	100.0	0.0
Total	-	**167.7**	**100.0**	-	-
K80	**261**				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 181.1 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	0.3	0.0	0.7	0.0	0.0
14	1.5	0.0	4.0	0.0	1.1
20	5.9	0.0	13.6	0.0	3.6
28	12.7	2.6	29.8	0.0	8.3
35	14.8	6.4	23.9	2.7	11.0
48	11.5	6.8	9.5	2.8	8.9
65	9.9	7.3	5.1	5.0	8.2
100	8.8	11.5	2.9	10.1	9.5
150	6.8	11.2	1.9	13.0	8.5
200	5.4	10.6	1.5	13.9	8.0
270	4.4	9.3	1.3	12.2	7.0
400	2.5	6.5	1.0	8.9	5.4
Pan	15.5	27.8	4.7	31.4	20.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	0.3	0.0
14	39 %	1.1	0.4
20	44 %	4.1	1.8
28	34 %	9.5	3.2
35	40 %	11.4	4.5
48	70 %	7.9	5.5
65	2678 %	5.2	139.3
100	38 %	9.2	3.5
150	40 %	8.5	3.4
200	42 %	7.9	3.3
270	45 %	6.8	3.1
400	51 %	4.6	2.4
Pan	46 %	23.4	10.8
Total	--	**100.0**	**181.1 %**

1. **Purpose:** To duplicate the conditions of test PP-2 but with an additional 50 kg of rods removed from the rod mill in order to reduce the buildup on the Sweco primary screen.

2. **Procedure:** The circuit remained unchanged, but 50 kg of rods were removed from the rod mill. Reagent levels were reduced slightly.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	53.7 % -100 mesh
Copper Head Grade	0.40 % Cu
Final Tails Grade	0.20 % Cu
Final Copper Grade	32.9 % Cu
Final Copper Recovery	50.6 %

The low rod charge in the rod mill succeeded in producing a relatively coarse screen feed, in anticipation of unit column flotation, but resulted in most of the grinding energy being expended in the ball mill. Although concentrate grade improved, it appears that collector levels were too low, and recoveries were accordingly low. The pre-cleaner continued to recovery the majority of metal values in the cleaning circuit, and further adjustments will be required to improve the balance between the pre-cleaner and the cleaner.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	198.3 kg/h	-1/4 inch	(Wet Sple 855.2 g)
			(Dry Sple 840.2 g)
Feed Rate:	194.8 kg/h	dry ore	(Moisture 1.75 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,355 kg in 6.83 hr	
	Sample	397 kg in 2.00 hr	
Rod Mill Discharge:	1,578 g/L		(58 % Sol at SG 2.73)
	60.2	% plus 48 mesh	
	26.9	% minus 100 mesh	
Input Power:	44.61	for 3 disc revolutions	
	0.87	kW (95% drive efficiency)	
Average Power:	0.83 kW	Gross	
	0.47 kW	No Load	
	0.35 kW	Net	
Net Power Usage:	1.82 kWh/t	of -1/4 inch feed	
K80 Feed:	4,283	microns	
K80 Product:	1,049	microns	
Work Index (metric):	11.6		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 120 % circ. load)
Feed Rate:	234.5 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,321 g/L		(38 % Sol at SG 2.73)
Ball Mill Discharge:	1,659 g/L		(63 % Sol at SG 2.73)
	52.1	% plus 48 mesh	
	29.9	% minus 100 mesh	
Input Power:	35.00	for 3 disc revolutions	
	1.11	kW (95% drive efficiency)	
Average Power:	1.06 kW	Gross	
	0.52 kW	No Load	
	0.53 kW	Net	
Net Power Usage:	2.27 kWh/t	of screen oversize	
K80 Feed:	1049	microns	
K80 Product:	314	microns	
Work Index (metric):	8.9		

3.1.3. Overall Mill Report:

Net Power Usage:	4.09 kWh/t
K80 Feed:	4,283 microns
K80 Product:	314 microns
Work Index (metric):	9.9
Screen Undersize:	53.7 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,283	14.0
Rod Mill Discharge	1,049	26.9
Screen Feed	849	28.1
Ball Mill Feed	1,029	9.6
Ball Mill Discharge	709	29.9
Screen Undersize	314	53.7
Rougher Feed	280	58.8
Regrind Feed	125	82.6
Regrind Discharge	35.0	99.4
Final Concentrate	68.4	97.7
Final Tail	289	56.6

3.2. Reagent Additions:

Average Feed Rate: 0.195 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	PAX	0.10%	6.2	1.91
	DF-250	0.10%	5.4	1.66
	Pine Oil	100%	4.8 dr	13.30
Scavenger Feed	PAX	0.10%	6.3	1.94
	DF-250	0.10%	4.9	1.51
	Pine Oil	0.10%	2.0	0.62
Scavenger Cell 4	PAX	0.10%	2.8	0.86
	DF-250	0.10%	3.0	0.92
Total	**PAX**			**4.71**
	DF-250			**4.10**
	Pine Oil			**13.92**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,578			2.73
Ball Mill Discharge	1,659			
Screen Undersize	1,321			
Rougher Feed		8.21	27	
Pre-Cleaner Feed		8.23		
Cleaner Feed		8.27		
Scavenger Tail	1,314			
Final Concentrate				3.87

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	200.8	1,321	6.6	12.7
Scavenger	168	195.2	1,318	6.5	25.8
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results: (120% circulating load)

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.40	1.34	0.40	1.38	194.8
Rod Mill Discharge			0.40	1.38	194.8
Ball Mill Discharge	0.21	1.00	0.17	0.84	234.5
Screen Feed	0.23	1.02	0.27	1.08	429.3
Screen Oversize	0.16	0.77	0.17	0.84	234.5
Screen Undersize	0.45	1.47	0.40	1.38	194.8
Rougher Feed	0.48	1.51	0.50	1.44	200.8
Rougher Conc	6.53	4.64	7.34	5.10	5.54
Rougher Tail	0.30	1.33	0.30	1.33	195.2
Scav Tail (final)	0.200	1.32	0.20	1.28	193.6
Scavenger Conc	12.2	6.80	12.2	6.95	1.63
Pre-Cleaner Feed	8.40	5.68	7.32	5.10	5.58
Pre-Cleaner Conc	37.9	19.1	38.1	19.0	0.99
Pre-Cleaner Tail	0.68	1.97	0.68	2.11	4.59
Cleaner Feed	0.73	2.64	0.68	2.11	4.59
Cleaner Conc	9.02	6.00	9.02	5.95	0.22
Cleaner Tail	0.26	2.37	0.26	1.91	4.37
Clnr-Scav Conc	4.31	4.69	4.31	4.69	0.04
Clnr-Scav Tail	0.23	2.49	0.22	1.89	4.33
Final Concentrate	32.9	16.5	32.9	16.6	1.21

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays Cu	Assays Fe	Distributions (%) Cu	Distributions (%) Fe
New Feed	100.00	0.40	1.38	100.0	100.0
Final Conc	0.62	32.9	16.6	50.6	7.5
Final Tail	99.38	0.201	1.28	49.4	92.5
Rougher Feed	103.06	0.50	1.44	126.6	107.2
Conc	2.84	7.34	5.10	51.8	10.5
Tail	100.22	0.30	1.33	74.8	96.7
Scavenger Feed	100.22	0.30	1.33	74.6	96.7
Conc	0.84	12.16	6.95	25.3	4.2
Tail	99.38	0.201	1.28	49.4	92.5
Combined Clnr Feed	2.84	7.34	5.10	51.8	10.5
Final Conc	0.62	32.9	16.6	50.6	7.5
Clnr/Scav Tail	2.22	0.22	1.89	1.2	3.0
Pre-Cleaner Feed	2.86	7.32	5.10	52.0	10.6
Conc	0.51	38.1	19.0	48.0	7.0
Tail	2.36	0.68	2.11	4.0	3.6
Cleaner Feed	2.36	0.68	2.11	4.0	3.6
Conc	0.11	9.0	5.95	2.5	0.5
Tail	2.24	0.26	1.91	1.4	3.1
Clnr/Scav Feed	2.24	0.26	1.91	1.4	3.1
Conc	0.02	4.31	4.69	0.2	0.1
Tail	2.22	0.22	1.89	1.2	3.0
Cleaners Only Feed	2.86	7.32	5.10	52.0	10.6
Final Conc	0.62	32.9	16.6	50.6	7.5
Cleaner Tail	2.24	0.26	1.91	1.4	3.1

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.0	0.40	1.38	100.0	100.0
Final Conc	0.62	32.9	16.6	50.6	7.5
Final Tail	99.4	0.201	1.28	49.4	92.5
Rougher Feed	100.0	0.50	1.44	100.0	100.0
Conc	2.8	7.34	5.10	40.9	9.8
Tail	97.2	0.30	1.33	59.1	90.2
Scavenger Feed	100.0	0.30	1.33	100.0	100.0
Conc	0.8	12.16	6.95	33.8	4.4
Tail	99.2	0.201	1.28	66.2	95.6
Combined Clnr Feed	100.0	7.34	5.10	100.0	100.0
Final Conc	21.8	32.9	16.6	97.7	71.1
Clnr/Scav Tail	78.2	0.222	1.889	2.3	28.9
Pre-Cleaner Feed	100.0	7.32	5.10	100.0	100.0
Conc	17.7	38.1	19.0	92.3	66.0
Tail	82.3	0.68	2.11	7.7	34.0
Cleaner Feed	100.0	0.68	2.11	100.0	100.0
Conc	4.75	9.0	5.95	63.4	13.4
Tail	95.2	0.26	1.91	36.6	86.6
Clnr/Scav Feed	100.0	0.26	1.91	100.0	100.0
Conc	0.89	4.31	4.69	14.8	2.2
Tail	99.1	0.22	1.89	85.2	97.8
Cleaners Only Feed	100.0	7.32	5.10	100.0	100.0
Final Conc	21.7	32.9	16.6	97.3	70.6
Cleaner Tail	78.3	0.26	1.91	2.7	29.4

5. Screen Analyses:

Detailed in the following pages.

Test No. PP-3

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	48.7	14.6	14.6	85.4
6	3,327	55.7	16.7	31.3	68.7
8	2,362	40.3	12.1	43.4	56.6
10	1,651	33.2	10.0	53.4	46.6
14	1,168	26.2	7.9	61.3	38.7
20	833	19.4	5.8	67.1	32.9
28	589	16.5	5.0	72.1	27.9
35	417	14.0	4.2	76.3	23.7
48	295	10.8	3.2	79.5	20.5
65	208	11.6	3.5	83.0	17.0
100	147	10.2	3.1	86.0	14.0
150	104	8.1	2.4	88.5	11.5
200	74	7.8	2.3	90.8	9.2
270	53	6.6	2.0	92.8	7.2
400	37	4.6	1.4	94.2	5.8
Pan	-37	19.4	5.8	100.0	0.0
Total	-	**333.1**	**100.0**	-	-
K80	**4,283**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.8	3.8	3.8	96.2
14	1,168	20.5	11.4	15.1	84.9
20	833	25.5	14.1	29.3	70.7
28	589	23.8	13.2	42.4	57.6
35	417	18.8	10.4	52.9	47.1
48	295	13.3	7.4	60.2	39.8
65	208	12.6	7.0	67.2	32.8
100	147	10.7	5.9	73.1	26.9
150	104	8.7	4.8	78.0	22.0
200	74	7.4	4.1	82.0	18.0
270	53	5.8	3.2	85.3	14.7
400	37	4.1	2.3	87.5	12.5
Pan	-37	22.5	12.5	100.0	0.0
Total	-	**180.5**	**100.0**	-	-
K80	**1,049**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	7.0	2.3	2.3	97.7
14	1,168	21.0	7.0	9.3	90.7
20	833	32.9	10.9	20.2	79.8
28	589	40.8	13.5	33.8	66.2
35	417	39.1	13.0	46.7	53.3
48	295	30.2	10.0	56.8	43.2
65	208	25.3	8.4	65.2	34.8
100	147	20.3	6.7	71.9	28.1
150	104	16.2	5.4	77.3	22.7
200	74	13.6	4.5	81.8	18.2
270	53	11.3	3.8	85.5	14.5
400	37	8.3	2.8	88.3	11.7
Pan	-37	35.3	11.7	100.0	0.0
Total	-	301.3	100.0	-	-
K80	849				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.2	0.6	0.6	99.4
14	1,168	25.2	11.7	12.3	87.7
20	833	42.4	19.7	32.0	68.0
28	589	54.2	25.2	57.1	42.9
35	417	39.3	18.3	75.4	24.6
48	295	17.6	8.2	83.6	16.4
65	208	9.5	4.4	88.0	12.0
100	147	5.3	2.5	90.4	9.6
150	104	3.0	1.4	91.8	8.2
200	74	2.0	0.9	92.8	7.2
270	53	1.6	0.7	93.5	6.5
400	37	1.2	0.6	94.1	5.9
Pan	-37	12.8	5.9	100.0	0.0
Total	-	215.3	100.0	-	-
K80	1,029				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	5.0	2.2	2.2	97.8
14	1,168	9.8	4.3	6.4	93.6
20	833	17.5	7.6	14.1	85.9
28	589	28.1	12.2	26.3	73.7
35	417	33.2	14.4	40.7	59.3
48	295	26.1	11.4	52.1	47.9
65	208	23.7	10.3	62.4	37.6
100	147	17.7	7.7	70.1	29.9
150	104	13.8	6.0	76.1	23.9
200	74	11.1	4.8	80.9	19.1
270	53	8.6	3.7	84.7	15.3
400	37	5.8	2.5	87.2	12.8
Pan	-37	29.4	12.8	100.0	0.0
Total	-	229.8	100.0	-	-
K80	709				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.0	0.9	0.9	99.1
35	417	10.2	9.2	10.1	89.9
48	295	13.6	12.2	22.3	77.7
65	208	13.2	11.9	34.2	65.8
100	147	13.5	12.1	46.3	53.7
150	104	10.1	9.1	55.4	44.6
200	74	9.0	8.1	63.5	36.5
270	53	8.1	7.3	70.8	29.2
400	37	6.1	5.5	76.3	23.7
Pan	-37	26.4	23.7	100.0	0.0
Total	-	111.2	100.0	-	-
K80	314				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.7	0.6	0.6	99.4
35	417	9.4	8.2	8.8	91.2
48	295	10.9	9.5	18.4	81.6
65	208	12.6	11.0	29.4	70.6
100	147	13.5	11.8	41.2	58.8
150	104	11.0	9.6	50.8	49.2
200	74	10.2	8.9	59.8	40.2
270	53	9.0	7.9	67.6	32.4
400	37	6.8	5.9	73.6	26.4
Pan	-37	30.2	26.4	100.0	0.0
Total	-	114.3	100.0	-	-
K80	280				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	1.8	2.4	2.4	97.6
48	295	3.0	4.0	6.4	93.6
65	208	3.8	5.1	11.5	88.5
100	147	4.4	5.9	17.4	82.6
150	104	4.3	5.8	23.2	76.8
200	74	4.7	6.3	29.5	70.5
270	53	6.0	8.0	37.5	62.5
400	37	4.7	6.3	43.8	56.2
Pan	-37	41.9	56.2	100.0	0.0
Total	-	74.6	100.0	-	-
K80	125				

Test No. PP-3

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.3	0.6	0.6	99.4
150	104	0.9	1.9	2.6	97.4
200	74	2.2	4.8	7.3	92.7
270	53	3.9	8.4	15.8	84.2
400	37	3.6	7.8	23.5	76.5
Pan	-37	35.4	76.5	100.0	0.0
Total	-	**46.3**	**100.0**	-	-
K80	**35.0**				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.5	0.7	0.7	99.3
100	147	1.2	1.6	2.3	97.7
150	104	4.4	5.9	8.1	91.9
200	74	6.8	9.1	17.2	82.8
270	53	8.7	11.6	28.8	71.2
400	37	8.6	11.5	40.2	59.8
Pan	-37	44.9	59.8	100.0	0.0
Total	-	**75.1**	**100.0**	-	-
K80	**68.4**				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.7	0.6	0.6	99.4
35	417	8.0	6.9	7.5	92.5
48	295	13.7	11.8	19.4	80.6
65	208	13.9	12.0	31.4	68.6
100	147	13.9	12.0	43.4	56.6
150	104	11.6	10.0	53.4	46.6
200	74	10.0	8.6	62.1	37.9
270	53	8.6	7.4	69.5	30.5
400	37	6.7	5.8	75.3	24.7
Pan	-37	28.6	24.7	100.0	0.0
Total	-	**115.7**	**100.0**	-	-
K80	**289**				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 109.6 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	3.8	0.0	0.6	2.2	2.3
14	11.4	0.0	11.7	4.3	7.0
20	14.1	0.0	19.7	7.6	10.9
28	13.2	0.9	25.2	12.2	13.5
35	10.4	9.2	18.3	14.4	13.0
48	7.4	12.2	8.2	11.4	10.0
65	7.0	11.9	4.4	10.3	8.4
100	5.9	12.1	2.5	7.7	6.7
150	4.8	9.1	1.4	6.0	5.4
200	4.1	8.1	0.9	4.8	4.5
270	3.2	7.3	0.7	3.7	3.8
400	2.3	5.5	0.6	2.5	2.8
Pan	12.5	23.7	5.9	12.8	11.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	3.8	0.0
14	153 %	7.1	10.8
20	117 %	10.6	12.4
28	95 %	12.7	12.1
35	33 %	11.4	3.7
48	153 %	9.8	14.9
65	83 %	8.5	7.0
100	119 %	6.9	8.2
150	92 %	5.4	5.0
200	102 %	4.5	4.6
270	136 %	3.5	4.8
400	163 %	2.4	4.0
Pan	165 %	13.5	22.1
Total	**--**	**100.0**	**109.6 %**

1. **Purpose:** To improve copper recovery by increasing collector (A-350) dosage in Scavenger Feed by 60%, from 1.9 to 3.2 g/t.

2. **Procedure:** No changes from test PP-3, but video camera operator was on site during plant startup and later in the day during the circuit sampling period.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	57.3 % -100 mesh
Copper Head Grade	0.35 % Cu
Final Tails Grade	0.10 % Cu
Final Copper Grade	37.6 % Cu
Final Copper Recovery	70.5 %

Copper recovery in the scavenger improved from 32% to 54%. The additional collector added to the scavenger, and distributed throughout the circuit in circulating loads, improved recoveries across all stages of flotation. As a result of better control of air and level in the pre-cleaner and cleaner stages, final concentrate grade improved from 32.9% Cu to 37.7% Cu. The head grade for this test, at 0.33% Cu, was 25% lower than in the previous test.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	192.6 kg/h	-1/4 inch	(Wet Sple 1033.1 g)
			(Dry Sple 1009.4 g)
Feed Rate:	188.2 kg/h	dry ore	(Moisture 2.29 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,252 kg in 6.50 hr	
	Sample	385 kg in 2.00 hr	
Rod Mill Discharge:	1,602 g/L		(59 % Sol at SG 2.75)
	57.5	% plus 48 mesh	
	28.4	% minus 100 mesh	
Input Power:	41.00	for 3	disc revolutions
	0.95	kW	(95% drive efficiency)
Average Power:	0.90 kW	Gross	
	0.47 kW	No Load	
	0.43 kW	Net	
Net Power Usage:	2.27 kWh/t	of -1/4 inch feed	
K80 Feed:	3,958	microns	
K80 Product:	912	microns	
Work Index (metric):	13.2		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 95 % circ. load)
Feed Rate:	179.4 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,352 g/L		(41 % Sol at SG 2.75)
Ball Mill Discharge:	1,636 g/L		(61 % Sol at SG 2.75)
	40.1	% plus 48 mesh	
	36.1	% minus 100 mesh	
Input Power:	35.08	for 3	disc revolutions
	1.11	kW	(95% drive efficiency)
Average Power:	1.05 kW	Gross	
	0.52 kW	No Load	
	0.53 kW	Net	
Net Power Usage:	2.95 kWh/t	of screen oversize	
K80 Feed:	912	microns	
K80 Product:	281	microns	
Work Index (metric):	11.1		

3.1.3. Overall Mill Report:

Net Power Usage:	5.22 kWh/t
K80 Feed:	3,958 microns
K80 Product:	281 microns
Work Index:	11.9 metric
Screen Undersize:	57.3 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	3,958	14.2
Rod Mill Discharge	912	28.4
Screen Feed	716	34.0
Ball Mill Feed	1,058	8.7
Ball Mill Discharge	508	36.1
Screen Undersize	281	57.3
Rougher Feed	242	62.8
Regrind Feed	73.3	85.8
Regrind Discharge	42.2	97.8
Final Concentrate	102	90.8
Final Tail	300	54.9

3.2. Reagent Additions:

Average Feed Rate: 0.188 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	PAX	0.10%	6.0	1.91
	DF-250	0.10%	4.1	1.31
	Pine Oil	100%	5.0 dr	14.35
Scavenger Feed	PAX	0.10%	9.9	3.16
	DF-250	0.10%	4.0	1.28
	Pine Oil	0.10%	2.0	0.64
Scavenger Cell 4	PAX	0.10%	2.6	0.83
	DF-250	0.10%	2.8	0.89
Total	**PAX**			**5.90**
	DF-250			**3.48**
	Pine Oil			**14.99**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,602			2.75
Ball Mill Discharge	1,636			
Screen Undersize	1,352			
Rougher Feed		8.20	21	
Pre-Cleaner Feed		8.19		
Cleaner Feed		8.15		
Scavenger Tail	1,345			
Final Concentrate				3.87

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	209.5	1,352	6.3	13.3
Scavenger	168	202.8	1,349	6.2	27.2
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results: (95% circulating load)

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

	Direct Assays		Adjusted Assays		Mass Flow
Product	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.39	1.40	0.35	1.61	188.2
Rod Mill Discharge			0.35	1.61	188.2
Ball Mill Discharge	0.17	1.03	0.18	0.96	179.4
Screen Feed	0.24	1.20	0.27	1.29	367.6
Screen Oversize	0.20	0.97	0.18	0.96	179.4
Screen Undersize	0.33	1.54	0.35	1.61	188.2
Rougher Feed	0.40	1.76	0.48	1.71	209.5
Rougher Conc	5.44	4.83	7.29	5.20	6.71
Rougher Tail	0.27	1.47	0.26	1.60	202.8
Scav Tail (final)	0.100	1.41	0.10	1.49	186.9
Scavenger Conc	2.2	2.82	2.07	2.83	15.80
Pre-Cleaner Feed	3.27	3.71	7.28	5.24	6.76
Pre-Cleaner Conc	38.5	19.7	38.3	19.4	1.11
Pre-Cleaner Tail	1.14	2.69	1.17	2.46	5.65
Cleaner Feed	1.17	2.97	1.17	2.46	5.65
Cleaner Conc	31.50	16.70	31.4	16.79	0.13
Cleaner Tail	0.53	2.62	0.48	2.13	5.53
Clnr-Scav Conc	16.00	10.40	15.82	10.46	0.06
Clnr-Scav Tail	0.40	2.72	0.32	2.04	5.47
Final Concentrate	37.8	19.3	37.6	19.2	1.23

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.00	0.35	1.61	100.0	100.0
Final Conc	0.66	37.6	19.2	70.5	7.8
Final Tail	99.34	0.104	1.49	29.5	92.2
Rougher Feed	111.31	0.48	1.71	152.3	118.5
Conc	3.56	7.29	5.20	74.2	11.5
Tail	107.74	0.26	1.60	78.1	107.0
Scavenger Feed	107.74	0.26	1.60	79.1	106.9
Conc	8.40	2.07	2.83	49.7	14.8
Tail	99.34	0.104	1.49	29.4	92.1
Combined Clnr Feed	3.56	7.29	5.20	74.2	11.5
Final Conc	0.66	37.6	19.2	70.5	7.8
Clnr/Scav Tail	2.91	0.32	2.04	3.7	3.7
Pre-Cleaner Feed	3.59	7.28	5.24	74.7	11.7
Conc	0.59	38.3	19.4	64.4	7.1
Tail	3.01	1.17	2.46	10.3	4.6
Cleaner Feed	3.01	1.17	2.46	10.1	4.6
Conc	0.07	31.4	16.79	6.1	0.7
Tail	2.94	0.48	2.13	4.0	3.9
Clnr/Scav Feed	2.94	0.48	2.13	4.0	3.9
Conc	0.03	15.82	10.46	1.4	0.2
Tail	2.91	0.32	2.04	2.6	3.7
Cleaners Only Feed	3.59	7.28	5.24	74.7	11.7
Final Conc	0.66	37.6	19.2	70.5	7.8
Cleaner Tail	2.94	0.48	2.13	4.2	3.9

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.0	0.35	1.61	100.0	100.0
Final Conc	0.66	37.6	19.2	70.5	7.8
Final Tail	99.3	0.104	1.49	29.5	92.2
Rougher Feed	100.0	0.48	1.71	100.0	100.0
Conc	3.2	7.29	5.20	48.7	9.7
Tail	96.8	0.26	1.60	51.3	90.3
Scavenger Feed	100.0	0.26	1.60	100.0	100.0
Conc	7.8	2.07	2.83	62.9	13.8
Tail	92.2	0.104	1.49	37.1	86.2
Combined Clnr Feed	100.0	7.29	5.20	100.0	100.0
Final Conc	18.4	37.6	19.2	95.0	67.8
Clnr/Scav Tail	81.6	0.320	2.041	5.0	32.2
Pre-Cleaner Feed	100.0	7.28	5.24	100.0	100.0
Conc	16.4	38.3	19.4	86.2	60.7
Tail	83.6	1.17	2.46	13.8	39.3
Cleaner Feed	100.0	1.17	2.46	100.0	100.0
Conc	2.26	31.4	16.79	60.6	15.5
Tail	97.7	0.48	2.13	39.4	84.5
Clnr/Scav Feed	100.0	0.48	2.13	100.0	100.0
Conc	1.02	15.82	10.46	33.9	5.0
Tail	99.0	0.32	2.04	66.1	95.0
Cleaners Only Feed	100.0	7.28	5.24	100.0	100.0
Final Conc	18.3	37.6	19.2	94.4	66.8
Cleaner Tail	81.7	0.48	2.13	5.6	33.2

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	53.8	12.0	12.0	88.0
6	3,327	67.6	15.1	27.0	73.0
8	2,362	56.5	12.6	39.6	60.4
10	1,651	49.0	10.9	50.6	49.4
14	1,168	40.2	9.0	59.5	40.5
20	833	29.2	6.5	66.0	34.0
28	589	25.3	5.6	71.7	28.3
35	417	20.8	4.6	76.3	23.7
48	295	15.8	3.5	79.8	20.2
65	208	13.8	3.1	82.9	17.1
100	147	13.2	2.9	85.8	14.2
150	104	10.8	2.4	88.2	11.8
200	74	10.2	2.3	90.5	9.5
270	53	9.7	2.2	92.7	7.3
400	37	6.4	1.4	94.1	5.9
Pan	-37	26.5	5.9	100.0	0.0
Total	-	448.8	100.0	-	-
K80	3,958				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.6	1.6	1.6	98.4
14	1,168	16.1	7.3	9.0	91.0
20	833	31.4	14.3	23.3	76.7
28	589	31.7	14.5	37.8	62.2
35	417	25.3	11.5	49.3	50.7
48	295	17.9	8.2	57.5	42.5
65	208	16.1	7.3	64.9	35.1
100	147	14.7	6.7	71.6	28.4
150	104	11.2	5.1	76.7	23.3
200	74	9.8	4.5	81.2	18.8
270	53	8.3	3.8	84.9	15.1
400	37	5.8	2.6	87.6	12.4
Pan	-37	27.2	12.4	100.0	0.0
Total	-	219.1	100.0	-	-
K80	912				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.5	1.4	1.4	98.6
14	1,168	8.5	4.9	6.3	93.7
20	833	15.4	8.8	15.1	84.9
28	589	19.3	11.0	26.1	73.9
35	417	20.7	11.8	37.9	62.1
48	295	18.2	10.4	48.3	51.7
65	208	15.8	9.0	57.3	42.7
100	147	15.1	8.6	66.0	34.0
150	104	11.5	6.6	72.5	27.5
200	74	9.3	5.3	77.8	22.2
270	53	8.1	4.6	82.5	17.5
400	37	5.6	3.2	85.7	14.3
Pan	-37	25.1	14.3	100.0	0.0
Total	-	175.1	100.0	-	-
K80	716				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	11.2	3.0	3.0	97.0
14	1,168	42.6	11.4	14.4	85.6
20	833	70.2	18.8	33.2	66.8
28	589	85.1	22.8	56.0	44.0
35	417	65.3	17.5	73.4	26.6
48	295	34.5	9.2	82.7	17.3
65	208	20.0	5.4	88.0	12.0
100	147	12.4	3.3	91.3	8.7
150	104	7.3	2.0	93.3	6.7
200	74	5.0	1.3	94.6	5.4
270	53	4.1	1.1	95.7	4.3
400	37	3.1	0.8	96.5	3.5
Pan	-37	12.9	3.5	100.0	0.0
Total	-	373.7	100.0	-	-
K80	1,058				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.5	0.7	0.7	99.3
14	1,168	4.1	1.9	2.7	97.3
20	833	8.4	4.0	6.6	93.4
28	589	16.8	8.0	14.6	85.4
35	417	26.8	12.7	27.3	72.7
48	295	27.0	12.8	40.1	59.9
65	208	27.9	13.2	53.3	46.7
100	147	22.4	10.6	63.9	36.1
150	104	16.2	7.7	71.5	28.5
200	74	12.8	6.1	77.6	22.4
270	53	10.8	5.1	82.7	17.3
400	37	7.2	3.4	86.1	13.9
Pan	-37	29.3	13.9	100.0	0.0
Total	-	211.2	100.0	-	-
K80	508				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.5	0.4	0.4	99.6
35	417	8.0	6.7	7.1	92.9
48	295	13.4	11.2	18.4	81.6
65	208	14.2	11.9	30.3	69.7
100	147	14.9	12.5	42.7	57.3
150	104	11.8	9.9	52.6	47.4
200	74	10.1	8.5	61.1	38.9
270	53	9.4	7.9	69.0	31.0
400	37	7.3	6.1	75.1	24.9
Pan	-37	29.7	24.9	100.0	0.0
Total	-	119.3	100.0	-	-
K80	281				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.3	0.2	0.2	99.8
35	417	6.0	4.2	4.4	95.6
48	295	13.8	9.7	14.1	85.9
65	208	13.8	9.7	23.9	76.1
100	147	18.9	13.3	37.2	62.8
150	104	14.7	10.3	47.5	52.5
200	74	12.9	9.1	56.6	43.4
270	53	11.3	8.0	64.5	35.5
400	37	8.6	6.1	70.6	29.4
Pan	-37	41.8	29.4	100.0	0.0
Total	-	**142.1**	**100.0**	-	-
K80	**242**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	2.2	2.7	2.7	97.3
48	295	4.1	5.0	7.7	92.3
65	208	3.3	4.0	11.8	88.2
100	147	2.0	2.5	14.2	85.8
150	104	1.7	2.1	16.3	83.7
200	74	2.9	3.6	19.9	80.1
270	53	4.6	5.6	25.5	74.5
400	37	5.5	6.7	32.2	67.8
Pan	-37	55.3	67.8	100.0	0.0
Total	-	**81.6**	**100.0**	-	-
K80	**73.3**				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.5	0.7	0.7	99.3
100	147	1.2	1.6	2.2	97.8
150	104	1.9	2.5	4.7	95.3
200	74	2.9	3.8	8.5	91.5
270	53	5.1	6.7	15.2	84.8
400	37	6.1	8.0	23.1	76.9
Pan	-37	58.8	76.9	100.0	0.0
Total	-	**76.5**	**100.0**	-	-
K80	**42.2**				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	4.5	2.3	2.3	97.7
100	147	13.6	6.9	9.2	90.8
150	104	19.7	10.0	19.3	80.7
200	74	25.7	13.1	32.4	67.6
270	53	26.4	13.5	45.8	54.2
400	37	21.7	11.1	56.9	43.1
Pan	-37	84.5	43.1	100.0	0.0
Total	-	**196.1**	**100.0**	-	-
K80	**101.7**				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.6	0.5	0.5	99.5
35	417	10.9	8.3	8.7	91.3
48	295	16.0	12.1	20.8	79.2
65	208	15.3	11.6	32.4	67.6
100	147	16.7	12.7	45.1	54.9
150	104	13.3	10.1	55.2	44.8
200	74	11.5	8.7	63.9	36.1
270	53	9.7	7.3	71.2	28.8
400	37	7.3	5.5	76.7	23.3
Pan	-37	30.7	23.3	100.0	0.0
Total	-	**132.0**	**100.0**	-	-
K80	**300**				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 91.3 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	1.6	0.0	3.0	0.7	1.4
14	7.3	0.0	11.4	1.9	4.9
20	14.3	0.0	18.8	4.0	8.8
28	14.5	0.4	22.8	8.0	11.0
35	11.5	6.7	17.5	12.7	11.8
48	8.2	11.2	9.2	12.8	10.4
65	7.3	11.9	5.4	13.2	9.0
100	6.7	12.5	3.3	10.6	8.6
150	5.1	9.9	2.0	7.7	6.6
200	4.5	8.5	1.3	6.1	5.3
270	3.8	7.9	1.1	5.1	4.6
400	2.6	6.1	0.8	3.4	3.2
Pan	12.4	24.9	3.5	13.9	14.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	1.6	0.0
14	78 %	5.0	3.9
20	97 %	9.2	8.9
28	95 %	11.3	10.7
35	101 %	12.1	12.3
48	86 %	10.3	8.9
65	58 %	9.5	5.5
100	79 %	8.4	6.7
150	84 %	6.3	5.2
200	85 %	5.2	4.4
270	102 %	4.5	4.5
400	135 %	3.1	4.2
Pan	120 %	13.5	16.1
Total	--	**100.0**	**91.3 %**

1. **Purpose:** No operational or reagent changes from test PP-4. Samples of concentrate from each of three rougher cells and six scavenger cells were collected to evaluate metal distribution down each bank. Also, the screen feed, rougher feed and final concentrate samples were submitted for size fraction analysis.

2. **Procedure:** No changes from test PP-4.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	58.9 % -100 mesh
Copper Head Grade	0.42 % Cu
Final Tails Grade	0.14 % Cu
Final Copper Grade	36.6 % Cu
Final Copper Recovery	66.4 %

The feed grade for this test was back up to 0.42% Cu. The feed grind was nearly identical to the previous test, as were the reagent dosages. In spite of this, the final concentrate grade dropped by 1% and the recovery dropped by 3%. The loss in recovery appears to have occurred in the scavenger, and is probably attributable to slight changes in air control. The scavenger froth is very light and poorly mineralized, and it is difficult to regulate scavenger production on the basis of physical appearance. Too much air in the scavenger inevitably results in excess froth production in the rougher. In the cleaning circuit, an attempt was made to balance the production between the pre-cleaner and the cleaner. This appears to have been detrimental, and the pre-cleaner should be allowed to pull the bulk of the final product.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	192.6 kg/h	-1/4 inch	(Wet Sple 972.8 g)
			(Dry Sple 949.0 g)
Feed Rate:	187.9 kg/h	dry ore	(Moisture 2.45 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,445 kg in 7.50 hr	
	Sample	385 kg in 2.00 hr	
Rod Mill Discharge:	1,598 g/L		(59 % Sol at SG 2.71)
	56.7	% plus 48 mesh	
	29.2	% minus 100 mesh	
Input Power:	41.00	for 3	disc revolutions
	0.95	kW	(95% drive efficiency)
Average Power:	0.90 kW	Gross	
	0.47 kW	No Load	
	0.43 kW	Net	
Net Power Usage:	2.27 kWh/t	of -1/4 inch feed	
K80 Feed:	4,076	microns	
K80 Product:	906	microns	
Work Index (metric):	12.9		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 77 % circ. load)
Feed Rate:	144.6 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,350 g/L		(41 % Sol at SG 2.71)
Ball Mill Discharge:	1,656 g/L		(63 % Sol at SG 2.71)
	35.4	% plus 48 mesh	
	40.4	% minus 100 mesh	
Input Power:	35.24	for 3	disc revolutions
	1.10	kW	(95% drive efficiency)
Average Power:	1.05 kW	Gross	
	0.52 kW	No Load	
	0.53 kW	Net	
Net Power Usage:	3.63 kWh/t	of screen oversize	
K80 Feed:	906	microns	
K80 Product:	281	microns	
Work Index (metric):	13.7		

3.1.3. Overall Mill Report:

Net Power Usage:	5.90 kWh/t
K80 Feed:	4,076 microns
K80 Product:	281 microns
Work Index (metric):	13.4
Screen Undersize:	58.9 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,076	14.5
Rod Mill Discharge	906	29.2
Screen Feed	747	32.0
Ball Mill Feed	1,070	8.2
Ball Mill Discharge	465	40.4
Screen Undersize	281	58.9
Rougher Feed	226	67.5
Regrind Feed	54.1	93.1
Regrind Discharge	41.3	98.3
Final Concentrate	95.6	92.3
Final Tail	281	56.3

3.2. Reagent Additions:

Average Feed Rate: 0.188 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	PAX	0.10%	6.2	1.98
	DF-250	0.10%	4.0	1.28
	Pine Oil	100%	5.2 dr	14.95
Scavenger Feed	PAX	0.10%	10.1	3.23
	DF-250	0.10%	3.9	1.25
	Pine Oil	0.10%	2.0	0.64
Scavenger Cell 4	PAX	0.10%	2.9	0.93
	DF-250	0.10%	2.7	0.86
Total	**PAX**			**6.13**
	DF-250			**3.38**
	Pine Oil			**15.58**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,598			2.71
Ball Mill Discharge	1,656			
Screen Undersize	1,350			
Rougher Feed		8.21	19.7	
Pre-Cleaner Feed		8.21		
Cleaner Feed		8.21		
Scavenger Tail	1,350			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	217.1	1,350	6.6	12.8
Scavenger	168	200.9	1,350	6.1	27.6
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.43	1.46	0.42	1.57	187.9
Rod Mill Discharge			0.42	1.57	187.9
Ball Mill Discharge	0.21	1.05	0.20	1.05	144.6
Screen Feed	0.32	1.39	0.33	1.34	332.5
Screen Oversize	0.19	1.03	0.20	1.05	144.6
Screen Undersize	0.42	1.70	0.42	1.57	187.9
Rougher Feed	0.40	1.87	0.46	1.78	217.1
Rougher Conc	3.25	4.10	3.44	4.07	16.1
Rougher Tail	0.22	1.68	0.22	1.59	200.9
Scav Tail (final)	0.14	1.48	0.14	1.44	186.4
Scavenger Conc	1.27	3.53	1.26	3.61	14.5
Pre-Cleaner Feed	2.52	3.40	3.33	4.05	16.6
Pre-Cleaner Conc	39.9	20.6	39.8	20.6	1.0
Pre-Cleaner Tail	0.99	2.95	1.69	3.16	12.4
Cleaner Feed	0.96	2.79	1.69	3.16	12.4
Cleaner Conc	29.4	16.1	29.3	16.2	0.4
Cleaner Tail	0.55	3.39	0.21	2.60	15.2
Clnr-Scav Conc	26.1	15.0	1.30	3.50	0.5
Clnr-Scav Tail	0.46	2.71	7.81	0.19	2.6
Final Concentrate	36.7	19.3	36.6	19.2	1.4
Rougher - Cell 1	13.3	8.64			
Rougher - Cell 2	0.92	2.88			
Rougher - Cell 3	0.33	2.49			
Scavenger - Cell 1	1.22	2.77			
Scavenger - Cell 2	0.70	2.56			
Scavenger - Cell 3	0.44	2.53			
Scavenger - Cell 4	1.06	2.81			
Scavenger - Cell 5	0.49	2.41			
Scavenger - Cell 6	0.65	2.39			

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.00	0.42	1.57	100.0	100.0
Final Conc	0.77	36.6	19.2	66.4	9.4
Final Tail	99.23	0.143	1.44	33.6	90.6
Rougher Feed	115.53	0.46	1.78	126.2	130.5
Conc	8.58	3.44	4.07	69.8	22.2
Tail	106.95	0.22	1.59	56.4	108.3
Scavenger Feed	106.95	0.22	1.59	56.6	108.3
Conc	7.72	1.26	3.61	23.0	17.7
Tail	99.23	0.143	1.44	33.6	90.6
Combined Clnr Feed	8.58	3.44	4.07	69.8	22.2
Final Conc	0.77	36.6	19.2	66.4	9.4
Clnr/Scav Tail	7.81	7.81	0.19	3.4	12.8
Pre-Cleaner Feed	8.83	3.33	4.05	69.6	22.8
Conc	0.54	39.8	20.6	50.4	7.0
Tail	6.58	1.69	3.16	19.2	15.7
Cleaner Feed	6.58	1.69	3.16	26.2	13.2
Conc	0.23	29.3	16.17	16.0	2.4
Tail	8.07	0.21	2.60	10.2	10.9
Clnr/Scav Feed	8.07	0.21	2.60	4.0	13.3
Conc	0.25	1.30	3.50	0.8	0.6
Tail	7.81	7.81	0.19	3.2	12.8
Cleaners Only Feed	8.83	3.33	4.05	69.6	22.8
Final Conc	0.77	36.6	19.2	66.4	9.4
Cleaner Tail	8.07	0.21	2.60	3.2	13.4

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays Cu	Assays Fe	Distributions (%) Cu	Distributions (%) Fe
New Feed	100.0	0.42	1.57	100.0	100.0
Final Conc	0.77	36.6	19.2	66.4	9.4
Final Tail	99.2	0.143	1.44	33.6	90.6
Rougher Feed	100.0	0.46	1.78	100.0	100.0
Conc	7.4	3.44	4.07	55.3	17.0
Tail	92.6	0.22	1.59	44.7	83.0
Scavenger Feed	100.0	0.22	1.59	100.0	100.0
Conc	7.2	1.26	3.61	40.7	16.4
Tail	92.8	0.143	1.44	59.3	83.6
Combined Clnr/Feed	100.0	3.44	4.07	100.0	100.0
Final Conc	8.9	36.6	19.2	95.1	42.3
Clnr/Scav Tail	91.1	7.814	0.192	4.9	57.7
Pre-Cleaner Feed	100.0	3.33	4.05	100.0	100.0
Conc	6.1	39.8	20.6	72.4	30.8
Tail	93.9	1.69	3.16	27.6	69.2
Cleaner Feed	100.0	1.69	3.16	100.0	100.0
Conc	3.51	29.3	16.17	61.0	18.0
Tail	96.5	0.21	2.60	39.0	82.0
Clnr/Scav Feed	100.0	0.21	2.60	100.0	100.0
Conc	3.12	1.30	3.50	19.3	4.2
Tail	96.9	7.81	0.19	80.7	95.8
Cleaners Only Feed	100.0	3.33	4.05	100.0	100.0
Final Conc	8.7	36.6	19.2	95.4	41.3
Cleaner Tail	91.3	0.21	2.60	4.6	58.7

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	51.6	13.1	13.1	86.9
6	3,327	60.4	15.3	28.4	71.6
8	2,362	47.9	12.2	40.6	59.4
10	1,651	42.0	10.7	51.3	48.7
14	1,168	34.0	8.6	59.9	40.1
20	833	24.8	6.3	66.2	33.8
28	589	21.0	5.3	71.5	28.5
35	417	17.5	4.4	76.0	24.0
48	295	13.3	3.4	79.3	20.7
65	208	13.5	3.4	82.8	17.2
100	147	10.9	2.8	85.5	14.5
150	104	9.3	2.4	87.9	12.1
200	74	8.8	2.2	90.1	9.9
270	53	7.9	2.0	92.1	7.9
400	37	6.0	1.5	93.7	6.3
Pan	-37	25.0	6.3	100.0	-
Total	-	**393.9**	**100.0**	-	-
K80	**4,076**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.1	1.6	1.6	98.4
14	1,168	15.3	7.9	9.5	90.5
20	833	26.1	13.5	22.9	77.1
28	589	27.0	13.9	36.9	63.1
35	417	22.2	11.4	48.3	51.7
48	295	16.3	8.4	56.7	43.3
65	208	14.9	7.7	64.4	35.6
100	147	12.5	6.4	70.8	29.2
150	104	10.0	5.2	76.0	24.0
200	74	8.5	4.4	80.4	19.6
270	53	7.4	3.8	84.2	15.8
400	37	5.7	2.9	87.1	12.9
Pan	-37	25.0	12.9	100.0	-
Total	-	**194.0**	**100.0**	-	-
K80	**906**				

Screen Feed

Size		Weight grams	% Retained		% Passing Cumulative
Mesh (Tyler)	µm		Individual	Cumulative	
10	1,651	2.7	1.5	1.5	98.5
14	1,168	10.0	5.5	7.0	93.0
20	833	17.3	9.5	16.4	83.6
28	589	20.2	11.1	27.5	72.5
35	417	21.8	12.0	39.5	60.5
48	295	19.0	10.4	49.9	50.1
65	208	17.8	9.8	59.6	40.4
100	147	15.3	8.4	68.0	32.0
150	104	11.4	6.3	74.3	25.7
200	74	9.0	4.9	79.2	20.8
270	53	7.6	4.2	83.4	16.6
400	37	4.9	2.7	86.1	13.9
Pan	-37	25.4	13.9	100.0	-
Total	-	**182.4**	**100.0**	-	-
K80	**747**				

Screen Oversize

Size		Weight grams	% Retained		% Passing Cumulative
Mesh (Tyler)	µm		Individual	Cumulative	
10	1,651	7.4	3.0	3.0	97.0
14	1,168	28.4	11.5	14.5	85.5
20	833	50.3	20.4	34.9	65.1
28	589	57.9	23.5	58.4	41.6
35	417	41.4	16.8	75.2	24.8
48	295	20.0	8.1	83.3	16.7
65	208	13.4	5.4	88.8	11.2
100	147	7.5	3.0	91.8	8.2
150	104	4.1	1.7	93.5	6.5
200	74	2.8	1.1	94.6	5.4
270	53	2.1	0.9	95.5	4.5
400	37	1.4	0.6	96.0	4.0
Pan	-37	9.8	4.0	100.0	-
Total	-	**246.5**	**100.0**	-	-
K80	**1,070**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.6	0.8	0.8	99.2
14	1,168	3.4	1.8	2.6	97.4
20	833	6.6	3.5	6.1	93.9
28	589	12.7	6.6	12.7	87.3
35	417	20.8	10.9	23.6	76.4
48	295	22.6	11.8	35.4	64.6
65	208	25.8	13.5	48.9	51.1
100	147	20.5	10.7	59.6	40.4
150	104	15.9	8.3	67.9	32.1
200	74	12.8	6.7	74.6	25.4
270	53	11.0	5.8	80.3	19.7
400	37	8.3	4.3	84.7	15.3
Pan	-37	29.3	15.3	100.0	-
Total	-	191.3	100.0	-	-
K80	465				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.5	0.4	0.4	99.6
35	417	9.7	7.5	7.8	92.2
48	295	14.2	10.9	18.7	81.3
65	208	13.2	10.1	28.9	71.1
100	147	15.9	12.2	41.1	58.9
150	104	12.9	9.9	51.0	49.0
200	74	11.3	8.7	59.7	40.3
270	53	10.4	8.0	67.7	32.3
400	37	8.1	6.2	73.9	26.1
Pan	-37	34.0	26.1	100.0	-
Total	-	130.2	100.0	-	-
K80	281				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.2	0.1	0.1	99.9
35	417	5.2	3.9	4.0	96.0
48	295	11.8	8.8	12.8	87.2
65	208	12.1	9.0	21.8	78.2
100	147	14.3	10.7	32.5	67.5
150	104	12.0	8.9	41.5	58.5
200	74	11.1	8.3	49.7	50.3
270	53	10.4	7.8	57.5	42.5
400	37	8.6	6.4	63.9	36.1
Pan	-37	48.4	36.1	100.0	-
Total	-	134.1	100.0	-	-
K80	226				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	1.1	1.2	1.2	98.8
48	295	1.1	1.2	2.5	97.5
65	208	2.0	2.2	4.7	95.3
100	147	2.0	2.2	6.9	93.1
150	104	2.0	2.2	9.2	90.8
200	74	3.8	4.2	13.4	86.6
270	53	6.3	7.0	20.4	79.6
400	37	6.3	7.0	27.5	72.5
Pan	-37	65.0	72.5	100.0	-
Total	-	89.6	100.0	-	-
K80	54.1				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.3	0.4	0.4	99.6
100	147	1.0	1.3	1.7	98.3
150	104	1.8	2.4	4.1	95.9
200	74	3.1	4.1	8.2	91.8
270	53	5.2	6.9	15.1	84.9
400	37	5.4	7.2	22.3	77.7
Pan	-37	58.5	77.7	100.0	-
Total	-	75.3	100.0	-	-
K80	35.0				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.9	1.9	1.9	98.1
100	147	5.8	5.8	7.7	92.3
150	104	9.1	9.1	16.9	83.1
200	74	11.8	11.8	28.7	71.3
270	53	12.9	12.9	41.6	58.4
400	37	8.8	8.8	50.5	49.5
Pan	-37	49.4	49.5	100.0	-
Total	-	99.7	100.0	-	-
K80	95.6				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.9	0.5	0.5	99.5
35	417	12.4	7.1	7.6	92.4
48	295	18.5	10.5	18.1	81.9
65	208	23.1	13.2	31.3	68.7
100	147	21.8	12.4	43.7	56.3
150	104	18.3	10.4	54.1	45.9
200	74	15.1	8.6	62.7	37.3
270	53	13.3	7.6	70.3	29.7
400	37	9.9	5.6	76.0	24.0
Pan	-37	42.2	24.0	100.0	-
Total	-	175.5	100.0	-	-
K80	281				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 76.6 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	1.6	0.0	3.0	0.8	1.5
14	7.9	0.0	11.5	1.8	5.5
20	13.5	0.0	20.4	3.5	9.5
28	13.9	0.4	23.5	6.6	11.1
35	11.4	7.5	16.8	10.9	12.0
48	8.4	10.9	8.1	11.8	10.4
65	7.7	10.1	5.4	13.5	9.8
100	6.4	12.2	3.0	10.7	8.4
150	5.2	9.9	1.7	8.3	6.3
200	4.4	8.7	1.1	6.7	4.9
270	3.8	8.0	0.9	5.8	4.2
400	2.9	6.2	0.6	4.3	2.7
Pan	12.9	26.1	4.0	15.3	13.9
Total	100.0	100.0	100.0	100.0	100.0

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	1.6	0.0
14	81 %	5.2	4.2
20	79 %	9.0	7.2
28	80 %	10.7	8.6
35	67 %	11.2	7.6
48	68 %	9.8	6.6
65	31 %	9.0	2.8
100	75 %	8.3	6.2
150	71 %	6.5	4.6
200	77 %	5.4	4.2
270	85 %	4.7	4.0
400	87 %	3.6	3.1
Pan	117 %	15.1	17.6
Total	--	100.0	76.6 %

1. **Purpose:** To duplicate the conditions of test PP-5 but with a slightly increased collector dosage to improve copper recovery.

2. **Procedure:** No changes from test PP-5.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	55.5 % -100 mesh
Copper Head Grade	0.34 % Cu
Final Tails Grade	0.13 % Cu
Final Copper Grade	34.3 % Cu
Final Copper Recovery	61.5 %

Overall grade and recovery both dropped, in spite of the slight increase in total collector dosage, from 6.1 to 6.6 g/t. Control of aeration rate in the roughers and scavengers continues to be the key. The mass flow rate of concentrates in the cleaning section are <0.5 Wt%, and the rate of distribution of the circulating loads is therefore very slow. Changes in aeration rate in the roughers or scavengers do not show up in cleaning for at least one hour.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	196.8 kg/h	-1/4 inch	(Wet Sple 1126.5 g)
			(Dry Sple 1102.3 g)
Feed Rate:	192.6 kg/h	dry ore	(Moisture 2.15 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,295 kg in 6.58 hr	
	Sample	394 kg in 2.00 hr	
Rod Mill Discharge:	1,614 g/L		(60 % Sol at SG 2.77)
	56.7	% plus 48 mesh	
	29.2	% minus 100 mesh	
Input Power:	42.00	for 3 disc revolutions	
	0.93	kW (95% drive efficiency)	
Average Power:	0.88 kW	Gross	
	0.47 kW	No Load	
	0.41 kW	Net	
Net Power Usage:	2.10 kWh/t	of -1/4 inch feed	
K80 Feed:	3,993	microns	
K80 Product:	986	microns	
Work Index (metric):	13.1		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 103 % circ. load)
Feed Rate:	197.8 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,348 g/L		(40 % Sol at SG 2.77)
Ball Mill Discharge:	1,692 g/L		(64 % Sol at SG 2.77)
	50.5	% plus 48 mesh	
	31.8	% minus 100 mesh	
Input Power:	34.46	for 3 disc revolutions	
	1.13	kW (95% drive efficiency)	
Average Power:	1.07 kW	Gross	
	0.52 kW	No Load	
	0.55 kW	Net	
Net Power Usage:	2.78 kWh/t	of screen oversize	
K80 Feed:	986	microns	
K80 Product:	310	microns	
Work Index (metric):	11.1		

3.1.3. Overall Mill Report:

Net Power Usage:	4.88 kWh/t
K80 Feed:	3,993 microns
K80 Product:	310 microns
Work Index (metric):	11.9
Screen Undersize:	55.5 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	3,993	14.3
Rod Mill Discharge	986	26.5
Screen Feed	896	27.9
Ball Mill Feed	1,129	7.3
Ball Mill Discharge	729	31.8
Screen Undersize	310	55.5
Rougher Feed	265	62.1
Regrind Feed	55.1	93.1
Regrind Discharge	47.8	97.5
Final Concentrate	86.6	94.3
Final Tail	301	55.5

3.2. Reagent Additions:

Average Feed Rate: 0.193 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	PAX	0.10%	7.0	2.18
	DF-250	0.10%	3.8	1.18
	Pine Oil	100%	5.4 dr	15.14
Scavenger Feed	PAX	0.10%	10.0	3.12
	DF-250	0.10%	4.0	1.25
	Pine Oil	0.10%	2.0	0.62
Scavenger Cell 4	PAX	0.10%	3.6	1.12
	DF-250	0.10%	3.0	0.93
Total	**PAX**			**6.42**
	DF-250			**3.36**
	Pine Oil			**15.77**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,614			2.75
Ball Mill Discharge	1,692			
Screen Undersize	1,348			
Rougher Feed		8.25	19	
Pre-Cleaner Feed		8.24		
Cleaner Feed		8.22		
Scavenger Tail	1,348			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	241.6	1,348	7.4	11.4
Scavenger	168	228.8	1,348	7.0	24.1
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.38	1.54	0.34	1.30	192.6
Rod Mill Discharge			0.34	1.30	192.6
Ball Mill Discharge	0.17	1.14	0.14	1.12	197.8
Screen Feed	0.29	1.30	0.24	1.21	390.3
Screen Oversize	0.22	1.01	0.14	1.12	197.8
Screen Undersize	0.30	1.54	0.34	1.30	192.6
Rougher Feed	0.43	1.79	0.46	1.65	241.6
Rougher Conc	4.77	4.71	3.51	4.57	12.8
Rougher Tail	0.24	1.52	0.28	1.49	228.8
Scav Tail (final)	0.13	1.54	0.13	1.20	191.4
Scavenger Conc	0.73	2.75	1.05	2.96	37.4
Pre-Cleaner Feed	2.20	3.49	3.74	4.60	12.9
Pre-Cleaner Conc	37.6	18.9	37.1	18.7	0.9
Pre-Cleaner Tail	1.05	2.92	1.18	2.61	12.0
Cleaner Feed	1.05	2.87	1.18	2.61	12.0
Cleaner Conc	26.7	14.6	26.4	14.8	0.3
Cleaner Tail	0.54	2.75	0.56	3.29	11.7
Clnr-Scav Conc	24.0	13.5	23.4	13.7	0.1
Clnr-Scav Tail	0.46	2.68	0.45	3.24	11.6
Final Concentrate	34.3	17.8	34.3	17.7	1.2
Rghr - Cell 1 Conc	14.1	8.95			
Rghr - Cell 1 Tail	0.31	1.74			
Rghr - Cell 2 Conc	0.65	2.70			
Rghr - Cell 2 Tail	0.25	1.68			
Rghr - Cell 3 Conc	0.33	2.50			

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.00	0.34	1.30	100.0	100.0
Final Conc	0.61	34.3	17.7	61.5	8.3
Final Tail	99.39	0.132	1.20	38.5	91.7
Rougher Feed	125.45	0.46	1.65	167.9	159.4
Conc	6.66	3.51	4.57	68.7	23.4
Tail	118.80	0.28	1.49	99.2	136.0
Scavenger Feed	118.80	0.28	1.49	98.5	136.0
Conc	19.41	1.05	2.96	59.8	44.3
Tail	99.39	0.132	1.20	38.8	91.7
Combined Clnr Feed	6.66	3.51	4.57	68.7	23.4
Final Conc	0.61	34.3	17.7	61.5	8.3
Clnr/Scav Tail	6.05	0.45	3.24	7.3	15.1
Pre-Cleaner Feed	6.69	3.74	4.60	73.6	23.7
Conc	0.45	37.1	18.7	49.4	6.5
Tail	6.23	1.18	2.61	24.3	17.2
Cleaner Feed	6.23	1.18	2.61	21.7	12.5
Conc	0.16	26.4	14.82	12.1	1.8
Tail	6.08	0.56	3.29	9.6	10.8
Clnr/Scav Feed	6.08	0.56	3.29	10.0	15.4
Conc	0.03	23.37	13.69	1.9	0.3
Tail	6.05	0.45	3.24	8.1	15.1
Cleaners Only Feed	6.69	3.74	4.60	73.6	23.7
Final Conc	0.61	34.3	17.7	61.5	8.3
Cleaner Tail	6.08	0.56	3.29	12.2	15.4

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.0	0.34	1.30	100.0	100.0
Final Conc	0.61	34.3	17.7	61.5	8.3
Final Tail	99.4	0.132	1.20	38.5	91.7
Rougher Feed	100.0	0.46	1.65	100.0	100.0
Conc	5.3	3.51	4.57	40.9	14.7
Tail	94.7	0.28	1.49	59.1	85.3
Scavenger Feed	100.0	0.28	1.49	100.0	100.0
Conc	16.3	1.05	2.96	60.6	32.6
Tail	83.7	0.132	1.20	39.4	67.4
Combined Clnr Feed	100.0	3.51	4.57	100.0	100.0
Final Conc	9.1	34.3	17.7	89.4	35.4
Clnr/Scav Tail	90.9	0.449	3.237	10.6	64.6
Pre-Cleaner Feed	100.0	3.74	4.60	100.0	100.0
Conc	6.8	37.1	18.7	67.1	27.5
Tail	93.2	1.18	2.61	32.9	72.5
Cleaner Feed	100.0	1.18	2.61	100.0	100.0
Conc	2.50	26.4	14.82	55.8	14.2
Tail	97.5	0.56	3.29	44.2	85.8
Clnr/Scav Feed	100.0	0.56	3.29	100.0	100.0
Conc	0.46	23.37	13.69	19.2	1.9
Tail	99.5	0.45	3.24	80.8	98.1
Cleaner Only Feed	100.0	3.74	4.60	100.0	100.0
Final Conc	9.1	34.3	17.7	83.5	35.0
Cleaner Tail	90.9	0.56	3.29	16.5	65.0

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	55.2	12.2	12.2	87.8
6	3,327	69.7	15.4	27.7	72.3
8	2,362	56.1	12.4	40.1	59.9
10	1,651	50.7	11.2	51.3	48.7
14	1,168	39.5	8.7	60.1	39.9
20	833	28.4	6.3	66.4	33.6
28	589	24.1	5.3	71.7	28.3
35	417	20.1	4.5	76.1	23.9
48	295	15.3	3.4	79.5	20.5
65	208	14.4	3.2	82.7	17.3
100	147	13.4	3.0	85.7	14.3
150	104	10.9	2.4	88.1	11.9
200	74	10.3	2.3	90.4	9.6
270	53	9.1	2.0	92.4	7.6
400	37	6.3	1.4	93.8	6.2
Pan	-37	28.0	6.2	100.0	-
Total	-	**451.5**	**100.0**	-	-
K80	**3,993**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.9	3.1	3.1	96.9
14	1,168	21.0	9.4	12.6	87.4
20	833	31.4	14.1	26.7	73.3
28	589	29.9	13.5	40.1	59.9
35	417	24.8	11.2	51.3	48.7
48	295	17.7	8.0	59.2	40.8
65	208	17.7	8.0	67.2	32.8
100	147	14.1	6.3	73.5	26.5
150	104	11.1	5.0	78.5	21.5
200	74	9.1	4.1	82.6	17.4
270	53	7.8	3.5	86.1	13.9
400	37	5.1	2.3	88.4	11.6
Pan	-37	25.7	11.6	100.0	-
Total	-	**222.3**	**100.0**	-	-
K80	**986**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	7.9	3.4	3.4	96.6
14	1,168	18.5	7.9	11.3	88.7
20	833	25.5	10.9	22.2	77.8
28	589	30.1	12.9	35.1	64.9
35	417	29.9	12.8	47.8	52.2
48	295	22.7	9.7	57.5	42.5
65	208	18.7	8.0	65.5	34.5
100	147	15.4	6.6	72.1	27.9
150	104	12.3	5.3	77.4	22.6
200	74	10.3	4.4	81.8	18.2
270	53	8.3	3.5	85.3	14.7
400	37	5.8	2.5	87.8	12.2
Pan	-37	28.5	12.2	100.0	-
Total	-	**233.9**	**100.0**	-	-
K80	**896**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	16.1	5.0	5.0	95.0
14	1,168	42.4	13.2	18.3	81.7
20	833	63.6	19.9	38.1	61.9
28	589	74.0	23.1	61.3	38.7
35	417	52.6	16.4	77.7	22.3
48	295	24.8	7.7	85.4	14.6
65	208	15.1	4.7	90.2	9.8
100	147	8.0	2.5	92.7	7.3
150	104	4.8	1.5	94.2	5.8
200	74	3.3	1.0	95.2	4.8
270	53	2.6	0.8	96.0	4.0
400	37	1.9	0.6	96.6	3.4
Pan	-37	10.9	3.4	100.0	-
Total	-	**320.1**	**100.0**	-	-
K80	**1,129**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	5.6	2.7	2.7	97.3
14	1,168	10.1	4.8	7.5	92.5
20	833	16.3	7.8	15.3	84.7
28	589	24.1	11.6	26.9	73.1
35	417	27.5	13.2	40.1	59.9
48	295	21.6	10.4	50.5	49.5
65	208	21.0	10.1	60.5	39.5
100	147	16.0	7.7	68.2	31.8
150	104	12.6	6.0	74.2	25.8
200	74	10.4	5.0	79.2	20.8
270	53	9.0	4.3	83.5	16.5
400	37	6.9	3.3	86.9	13.1
Pan	-37	27.4	13.1	100.0	0.0
Total	-	**208.5**	**100.0**	-	-
K80	**729**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.1	0.7	0.7	99.3
35	417	13.5	8.6	9.3	90.7
48	295	21.4	13.6	22.9	77.1
65	208	14.4	9.2	32.1	67.9
100	147	19.5	12.4	44.5	55.5
150	104	15.5	9.9	54.3	45.7
200	74	13.1	8.3	62.7	37.3
270	53	11.8	7.5	70.2	29.8
400	37	7.7	4.9	75.1	24.9
Pan	-37	39.2	24.9	100.0	-
Total	-	**157.2**	**100.0**	-	-
K80	**310**				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.8	0.6	0.6	99.4
35	417	9.9	7.4	8.0	92.0
48	295	11.4	8.6	16.6	83.4
65	208	14.0	10.5	27.1	72.9
100	147	14.4	10.8	37.9	62.1
150	104	10.8	8.1	46.0	54.0
200	74	9.7	7.3	53.3	46.7
270	53	8.6	6.5	59.8	40.2
400	37	5.7	4.3	64.0	36.0
Pan	-37	47.9	36.0	100.0	-
Total	-	133.2	100.0	-	-
K80	265				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	2.4	2.5	2.5	97.5
65	208	2.2	2.3	4.7	95.3
100	147	2.1	2.2	6.9	93.1
150	104	2.5	2.6	9.5	90.5
200	74	4.2	4.3	13.8	86.2
270	53	6.7	6.9	20.7	79.3
400	37	6.2	6.4	27.1	72.9
Pan	-37	70.6	72.9	100.0	-
Total	-	96.9	100.0	-	-
K80	55.1				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.1	1.0	1.0	99.0
100	147	1.7	1.5	2.5	97.5
150	104	2.9	2.6	5.2	94.8
200	74	5.3	4.8	10.0	90.0
270	53	8.6	7.8	17.8	82.2
400	37	8.4	7.6	25.4	74.6
Pan	-37	82.1	74.6	100.0	-
Total	-	**110.1**	**100.0**	-	-
K80	**35.0**				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.2	1.0	1.0	99.0
100	147	5.6	4.7	5.7	94.3
150	104	10.1	8.5	14.2	85.8
200	74	12.2	10.2	24.4	75.6
270	53	13.6	11.4	35.8	64.2
400	37	11.3	9.5	45.3	54.7
Pan	-37	65.3	54.7	100.0	-
Total	-	**119.3**	**100.0**	-	-
K80	**86.6**				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.9	0.6	0.6	99.4
35	417	11.6	8.3	9.0	91.0
48	295	16.6	11.9	20.9	79.1
65	208	15.9	11.4	32.4	67.6
100	147	16.9	12.1	44.5	55.5
150	104	13.7	9.8	54.3	45.7
200	74	12.0	8.6	63.0	37.0
270	53	10.0	7.2	70.2	29.8
400	37	7.4	5.3	75.5	24.5
Pan	-37	34.1	24.5	100.0	-
Total	-	**139.1**	**100.0**	-	-
K80	**301**				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 110.2 %

Mesh	Direct Screen Analyses				
	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	3.1	0.0	5.0	2.7	3.4
14	9.4	0.0	13.2	4.8	7.9
20	14.1	0.0	19.9	7.8	10.9
28	13.5	0.7	23.1	11.6	12.9
35	11.2	8.6	16.4	13.2	12.8
48	8.0	13.6	7.7	10.4	9.7
65	8.0	9.2	4.7	10.1	8.0
100	6.3	12.4	2.5	7.7	6.6
150	5.0	9.9	1.5	6.0	5.3
200	4.1	8.3	1.0	5.0	4.4
270	3.5	7.5	0.8	4.3	3.5
400	2.3	4.9	0.6	3.3	2.5
Pan	11.6	24.9	3.4	13.1	12.2
Total	100.0	100.0	100.0	100.0	100.0

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	3.1	0.0
14	112 %	7.0	7.9
20	117 %	10.7	12.6
28	110 %	12.5	13.7
35	79 %	12.1	9.5
48	216 %	9.6	20.8
65	22 %	8.3	1.9
100	117 %	7.1	8.3
150	107 %	5.5	5.9
200	107 %	4.6	4.9
270	114 %	3.9	4.5
400	96 %	2.8	2.7
Pan	137 %	12.8	17.6
Total	--	100.0	110.2 %

1. **Purpose:** To duplicate the conditions of test PP-6 but with a slight reduction in Pine Oil frother in the roughing stage.

2. **Procedure:** No changes from test PP-6.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	54.8 % -100 mesh
Copper Head Grade	0.35 % Cu
Final Tails Grade	0.13 % Cu
Final Copper Grade	39.3 % Cu
Final Copper Recovery	63.2 %

The dosage of Pine Oil was reduced by 25% to about 12 g/t, in order to reduce frothing.
No changes were made to the circuit, but much time was spent adjusting aeration rates in all stages. It was observed that aeration control was very touchy, and the circuit response to even small changes in earation rate were significant.
For example, a slight increase in aeration rate in the scavenger resulted in a significant increase in frothing in the roughers, allowing about one hour for the effects of the circulating load.
Grade improved from 34 to 39% Cu, and recovery improved from 57 to 58%.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	197.2 kg/h	-1/4 inch	(Wet Sple 1945.0 g) (Dry Sple 1898.4 g)
Feed Rate:	192.5 kg/h	dry ore	(Moisture 2.40 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1429.7 in 7.25 hr	
	Sample	591.6 in 3.00 hr	
Rod Mill Discharge:	1,604 g/L		(59 % Sol at SG 2.73)
	59.1	% plus 48 mesh	
	28.0	% minus 100 mesh	
Input Power:	41.52	for 3 disc revolutions	
	0.94	kW (95% drive efficiency)	
Average Power:	0.89 kW	Gross	
	0.47 kW	No Load	
	0.42 kW	Net	
Net Power Usage:	2.16 kWh/t	of -1/4 inch feed	
K80 Feed:	4,144	microns	
K80 Product:	1,012	microns	
Work Index (metric):	13.6		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 94 % circ. load)
Feed Rate:	180.1 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,350 g/L		(41 % Sol at SG 2.73)
Ball Mill Discharge:	1,639 g/L		(62 % Sol at SG 2.73)
	49.7	% plus 48 mesh	
	30.8	% minus 100 mesh	
Input Power:	34.60	for 3 disc revolutions	
	1.12	kW (95% drive efficiency)	
Average Power:	1.07 kW	Gross	
	0.52 kW	No Load	
	0.54 kW	Net	
Net Power Usage:	3.02 kWh/t	of screen oversize	
K80 Feed:	1012	microns	
K80 Product:	307	microns	
Work Index (metric):	11.8		

3.1.3. Overall Mill Report:

Net Power Usage:	5.18 kWh/t
K80 Feed:	4,144 microns
K80 Product:	307 microns
Work Index (metric):	12.5
Screen Undersize:	54.8 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,144	15.7
Rod Mill Discharge	1,012	28.0
Screen Feed	827	28.1
Ball Mill Feed	1,107	7.7
Ball Mill Discharge	644	30.8
Screen Undersize	307	54.8
Rougher Feed	315	54.3
Regrind Feed	~16	96.1
Regrind Discharge	~11	99.7
Final Concentrate	89.8	94.1
Final Tail	301	53.9

3.2. Reagent Additions:

Average Feed Rate: 0.192 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	PAX	0.10%	7.1	2.21
	DF-250	0.10%	5.1	1.59
	Pine Oil	100%	4.0 dr	11.22
Scavenger Feed	PAX	0.10%	10.0	3.12
	DF-250	0.10%	4.0	1.25
	Pine Oil	0.10%	2.0	0.62
Scavenger Cell 4	PAX	0.10%	3.6	1.12
	DF-250	0.10%	2.7	0.84
Total	**PAX**			**6.45**
	DF-250			**3.68**
	Pine Oil			**11.85**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,604			2.73
Ball Mill Discharge	1,639			
Screen Undersize	1,350			
Rougher Feed		8.33	15.9	
Pre-Cleaner Feed		8.35		
Cleaner Feed		8.40		
Scavenger Tail	1,350			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	198.3	1,350	6.0	14.0
Scavenger	168	195.9	1,350	5.9	28.3
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.41	1.58	0.35	1.59	192.5
Rod Mill Discharge			0.35	1.59	192.5
Ball Mill Discharge	0.15	1.04	0.16	1.00	180.1
Screen Feed	0.29	1.27	0.26	1.30	372.6
Screen Oversize	0.15	0.96	0.16	1.00	180.1
Screen Undersize	0.31	1.61	0.35	1.59	192.5
Rougher Feed	0.47	1.70	0.46	1.66	198.3
Rougher Conc	18.30	10.80	18.0	9.24	2.4
Rougher Tail	0.24	1.56	0.24	1.56	195.9
Scav Tail (final)	0.13	1.50	0.13	1.50	191.4
Scavenger Conc	5.02	4.20	4.99	4.11	4.5
Pre-Cleaner Feed	10.70	6.78	17.7	9.18	2.5
Pre-Cleaner Conc	40.2	20.9	40.0	16.7	1.0
Pre-Cleaner Tail	1.72	3.28	1.99	3.89	1.5
Cleaner Feed	1.63	3.99	1.99	3.89	1.5
Cleaner Conc	26.6	14.9	26.3	15.9	0.1
Cleaner Tail	0.69	3.54	0.78	3.39	1.4
Clnr-Scav Conc	7.2	7.0	6.74	7.02	0.1
Clnr-Scav Tail	0.38	3.16	0.44	3.06	1.3
Final Concentrate	39.3	21.1	39.3	16.6	1.1

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.00	0.35	1.59	100.0	100.0
Final Conc	0.57	39.3	16.6	63.2	5.9
Final Tail	99.43	0.131	1.50	36.8	94.1
Rougher Feed	103.03	0.46	1.66	133.7	107.4
Conc	1.26	17.97	9.24	64.0	7.3
Tail	101.77	0.24	1.56	69.7	100.1
Scavenger Feed	101.77	0.24	1.56	69.8	100.1
Conc	2.34	4.99	4.11	33.0	6.0
Tail	99.43	0.131	1.50	36.8	94.1
Combined Clnr Feed	1.26	17.97	9.24	64.0	7.3
Final Conc	0.57	39.3	16.6	63.2	5.9
Clnr/Scav Tail	0.69	0.44	3.06	0.8	1.4
Pre-Cleaner Feed	1.30	17.65	9.18	64.8	7.5
Conc	0.54	40.0	16.7	60.7	5.6
Tail	0.76	1.99	3.89	4.1	1.9
Cleaner Feed	0.76	1.99	3.89	4.3	1.9
Conc	0.03	26.3	15.86	2.4	0.3
Tail	0.73	0.78	3.39	1.9	1.5
Clnr/Scav Feed	0.73	0.78	3.39	1.6	1.6
Conc	0.04	6.74	7.02	0.7	0.2
Tail	0.69	0.44	3.06	0.9	1.4
Cleaners Only Feed	1.30	17.65	9.18	64.8	7.5
Final Conc	0.57	39.3	16.6	63.2	5.9
Cleaner Tail	0.73	0.78	3.39	1.6	1.5

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.0	0.35	1.59	100.0	100.0
Final Conc	0.57	39.3	16.6	63.2	5.9
Final Tail	99.4	0.131	1.50	36.8	94.1
Rougher Feed	100.0	0.46	1.66	100.0	100.0
Conc	1.2	17.97	9.24	47.9	6.8
Tail	98.8	0.24	1.56	52.1	93.2
Scavenger Feed	100.0	0.24	1.56	100.0	100.0
Conc	2.3	4.99	4.11	47.3	6.0
Tail	97.7	0.131	1.50	52.7	94.0
Combined Clnr Feed	100.0	17.97	9.24	100.0	100.0
Final Conc	45.2	39.3	16.6	98.7	81.1
Clnr/Scav Tail	54.8	0.435	3.055	1.3	18.9
Pre-Cleaner Feed	100.0	17.65	9.18	100.0	100.0
Conc	41.3	40.0	16.7	93.7	75.0
Tail	58.7	1.99	3.89	6.3	25.0
Cleaner Feed	100.0	1.99	3.89	100.0	100.0
Conc	4.21	26.3	15.86	55.7	17.2
Tail	95.8	0.78	3.39	44.3	82.8
Clnr/Scav Feed	100.0	0.78	3.39	100.0	100.0
Conc	5.22	6.74	7.02	45.0	10.8
Tail	94.8	0.44	3.06	55.0	89.2
Cleaners Only Feed	100.0	17.65	9.18	100.0	100.0
Final Conc	43.9	39.3	16.6	97.5	79.3
Cleaner Tail	56.1	0.78	3.39	2.5	20.7

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	56.3	13.4	13.4	86.6
6	3,327	69.8	16.7	30.1	69.9
8	2,362	49.4	11.8	41.9	58.1
10	1,651	49.4	11.8	53.7	46.3
14	1,168	33.6	8.0	61.7	38.3
20	833	25.4	6.1	67.7	32.3
28	589	20.6	4.9	72.7	27.3
35	417	17.0	4.1	76.7	23.3
48	295	12.7	3.0	79.7	20.3
65	208	7.8	1.9	81.6	18.4
100	147	11.2	2.7	84.3	15.7
150	104	10.0	2.4	86.7	13.3
200	74	9.0	2.1	88.8	11.2
270	53	7.6	1.8	90.6	9.4
400	37	5.6	1.3	92.0	8.0
Pan	-37	33.7	8.0	100.0	-
Total	-	**419.1**	**100.0**	-	-
K80	**4,144**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	8.3	3.1	3.1	96.9
14	1,168	28.6	10.7	13.8	86.2
20	833	36.9	13.8	27.5	72.5
28	589	35.0	13.1	40.6	59.4
35	417	28.2	10.5	51.1	48.9
48	295	21.4	8.0	59.1	40.9
65	208	17.3	6.5	65.6	34.4
100	147	17.3	6.5	72.0	28.0
150	104	13.7	5.1	77.1	22.9
200	74	11.6	4.3	81.5	18.5
270	53	9.8	3.7	85.1	14.9
400	37	6.2	2.3	87.4	12.6
Pan	-37	33.7	12.6	100.0	-
Total	-	**268.0**	**100.0**	-	-
K80	**1,012**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.7	2.5	2.5	97.5
14	1,168	13.5	7.2	9.8	90.2
20	833	18.9	10.1	19.9	80.1
28	589	23.4	12.5	32.4	67.6
35	417	23.9	12.8	45.2	54.8
48	295	18.8	10.1	55.3	44.7
65	208	17.7	9.5	64.8	35.2
100	147	13.2	7.1	71.9	28.1
150	104	10.2	5.5	77.3	22.7
200	74	8.2	4.4	81.7	18.3
270	53	6.8	3.6	85.4	14.6
400	37	5.1	2.7	88.1	11.9
Pan	-37	22.2	11.9	100.0	-
Total	-	**186.6**	**100.0**	-	-
K80	**827**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	12.7	3.8	3.8	96.2
14	1,168	43.8	13.3	17.1	82.9
20	833	63.3	19.2	36.3	63.7
28	589	75.5	22.9	59.1	40.9
35	417	56.6	17.1	76.3	23.7
48	295	27.8	8.4	84.7	15.3
65	208	16.2	4.9	89.6	10.4
100	147	8.8	2.7	92.3	7.7
150	104	4.9	1.5	93.8	6.2
200	74	3.5	1.1	94.8	5.2
270	53	2.7	0.8	95.6	4.4
400	37	1.8	0.5	96.2	3.8
Pan	-37	12.6	3.8	100.0	-
Total	-	**330.2**	**100.0**	-	-
K80	**1,107**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.8	1.7	1.7	98.3
14	1,168	8.2	3.7	5.5	94.5
20	833	13.3	6.1	11.5	88.5
28	589	23.7	10.8	22.3	77.7
35	417	31.8	14.5	36.8	63.2
48	295	28.1	12.8	49.7	50.3
65	208	22.9	10.4	60.1	39.9
100	147	20.0	9.1	69.2	30.8
150	104	14.5	6.6	75.8	24.2
200	74	11.1	5.1	80.9	19.1
270	53	9.3	4.2	85.1	14.9
400	37	5.9	2.7	87.8	12.2
Pan	-37	26.7	12.2	100.0	-
Total	-	**219.3**	**100.0**	-	-
K80	**644**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.3	0.8	0.8	99.2
35	417	13.8	8.8	9.6	90.4
48	295	19.2	12.2	21.9	78.1
65	208	16.8	10.7	32.6	67.4
100	147	19.8	12.6	45.2	54.8
150	104	15.1	9.6	54.8	45.2
200	74	13.2	8.4	63.2	36.8
270	53	11.3	7.2	70.4	29.6
400	37	7.6	4.8	75.3	24.7
Pan	-37	38.8	24.7	100.0	-
Total	-	**156.9**	**100.0**	-	-
K80	**307**				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.5	0.9	0.9	99.1
35	417	17.3	10.0	10.8	89.2
48	295	20.4	11.8	22.6	77.4
65	208	18.6	10.7	33.3	66.7
100	147	21.5	12.4	45.7	54.3
150	104	17.0	9.8	55.5	44.5
200	74	14.1	8.1	63.6	36.4
270	53	12.2	7.0	70.6	29.4
400	37	8.9	5.1	75.7	24.3
Pan	-37	42.1	24.3	100.0	-
Total	-	**173.6**	**100.0**	-	-
K80	**315**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	2.1	2.5	2.5	97.5
100	147	1.2	1.4	3.9	96.1
150	104	1.0	1.2	5.0	95.0
200	74	1.2	1.4	6.4	93.6
270	53	2.6	3.0	9.5	90.5
400	37	2.2	2.6	12.1	87.9
Pan	-37	75.0	87.9	100.0	-
Total	-	**85.3**	**100.0**	-	-
K80	**~16**				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.1	0.1	0.1	99.9
100	147	0.1	0.1	0.3	99.7
150	104	0.5	0.7	0.9	99.1
200	74	1.2	1.6	2.5	97.5
270	53	2.2	2.9	5.4	94.6
400	37	2.5	3.3	8.6	91.4
Pan	-37	69.8	91.4	100.0	-
Total	-	76.4	100.0	-	-
K80	~11				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.7	1.1	1.1	98.9
100	147	7.8	4.9	5.9	94.1
150	104	13.9	8.7	14.6	85.4
200	74	19.0	11.9	26.5	73.5
270	53	20.4	12.8	39.3	60.8
400	37	17.4	10.9	50.1	49.9
Pan	-37	79.8	49.9	100.0	-
Total	-	160.0	100.0	-	-
K80	89.8				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.2	0.6	0.6	99.4
35	417	16.6	7.8	8.4	91.6
48	295	26.1	12.3	20.7	79.3
65	208	27.1	12.8	33.5	66.5
100	147	26.8	12.6	46.1	53.9
150	104	21.1	9.9	56.1	43.9
200	74	17.4	8.2	64.3	35.7
270	53	14.6	6.9	71.1	28.9
400	37	7.9	3.7	74.9	25.1
Pan	-37	53.3	25.1	100.0	-
Total	-	212.1	100.0	-	-
K80	301				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 97.4 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	3.1	0.0	3.8	1.7	2.5
14	10.7	0.0	13.3	3.7	7.2
20	13.8	0.0	19.2	6.1	10.1
28	13.1	0.8	22.9	10.8	12.5
35	10.5	8.8	17.1	14.5	12.8
48	8.0	12.2	8.4	12.8	10.1
65	6.5	10.7	4.9	10.4	9.5
100	6.5	12.6	2.7	9.1	7.1
150	5.1	9.6	1.5	6.6	5.5
200	4.3	8.4	1.1	5.1	4.4
270	3.7	7.2	0.8	4.2	3.6
400	2.3	4.8	0.5	2.7	2.7
Pan	12.6	24.7	3.8	12.2	11.9
Total	100.0	100.0	100.0	100.0	100.0

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	3.1	0.0
14	112 %	7.0	7.9
20	105 %	9.8	10.3
28	101 %	11.9	12.1
35	65 %	12.1	7.9
48	97 %	10.4	10.0
65	77 %	8.2	6.3
100	95 %	7.8	7.4
150	88 %	5.8	5.1
200	102 %	4.7	4.8
270	104 %	4.0	4.1
400	118 %	2.5	3.0
Pan	145 %	12.8	18.6
Total	–	100.0	97.4 %

1. **Purpose:** To improve recovery by increasing collector dosages across the board.

2. **Procedure:** No changes in flowsheet from test PP-7. Collector dosage was increased by 0.75 g/t in the rougher, by 0.5 g/t in the scavenger feed and by 1.2 g/t in the scavenger fourth cell.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	59.9 % -100 mesh
Copper Head Grade	0.35 % Cu
Final Tails Grade	0.10 % Cu
Final Copper Grade	37.7 % Cu
Final Copper Recovery	70.1 %

An incorrect dilution water setting in the ball mill feed flow resulted in an imbalance in the grinding circuit. The higher water flow flushed material through the ball mill too quickly, and circulating load rose to the point that pumping problems began to occur. The final grinding circuit product dropped from 60% -100 mesh to only 47% -100 mesh. At this coarse size, the metallurgical performance appeared to be fairly good, but plugging problems in the grinding circuit probably resulted in unstable conditions in the flotation circuit during the sampling period.

The adverse effects of grinding circuit upsets may have been partially overcome by the increased collector dosage (increased from 6 to 9 g/t).

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	200.4 kg/h	-1/4 inch	(Wet Sple 1026.3 g)
			(Dry Sple 1002.9 g)
Feed Rate:	195.8 kg/h	dry ore	(Moisture 2.28 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,002 kg in 5.00 hr	
	Sample	601 kg in 3.00 hr	
Rod Mill Discharge:	1,607 g/L		(59 % Sol at SG 2.75)
	61.2	% plus 48 mesh	
	26.1	% minus 100 mesh	
Input Power:	42.32	for 3	disc revolutions
	0.92	kW	(95% drive efficiency)
Average Power:	0.87 kW	Gross	
	0.47 kW	No Load	
	0.40 kW	Net	
Net Power Usage:	2.04 kWh/t	of -1/4 inch feed	
K80 Feed:	4,145	microns	
K80 Product:	1,065	microns	
Work Index (metric):	13.5		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 158 % circ. load)
Feed Rate:	308.5 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,314 g/L		(38 % Sol at SG 2.75)
Ball Mill Discharge:	1,644 g/L		(62 % Sol at SG 2.75)
	62.5	% plus 48 mesh	
	22.9	% minus 100 mesh	
Input Power:	34.60	for 3	disc revolutions
	1.12	kW	(95% drive efficiency)
Average Power:	1.07 kW	Gross	
	0.52 kW	No Load	
	0.54 kW	Net	
Net Power Usage:	1.77 kWh/t	of screen oversize	
K80 Feed:	1065	microns	
K80 Product:	274	microns	
Work Index (metric):	5.9		

3.1.3. Overall Mill Report:

Net Power Usage:	3.80 kWh/t
K80 Feed:	4,145 microns
K80 Product:	274 microns
Work Index (metric):	8.5
Screen Undersize:	59.9 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	4,144	15.7
Rod Mill Discharge	1,012	28.0
Screen Feed	827	28.1
Ball Mill Feed	1,107	7.7
Ball Mill Discharge	644	30.8
Screen Undersize	307	54.8
Rougher Feed	315	54.3
Regrind Feed	~16	96.1
Regrind Discharge	~11	99.7
Final Concentrate	89.8	94.1
Final Tail	301	53.9

3.2. Reagent Additions:

Average Feed Rate: 0.196 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	PAX	0.10%	10.0	3.06
	DF-250	0.10%	3.9	1.19
	Pine Oil	100%	4.1 dr	11.31
Scavenger Feed	PAX	0.10%	12.1	3.71
	DF-250	0.10%	4.0	1.23
	Pine Oil	0.10%	2.0	0.61
Scavenger Cell 4	PAX	0.10%	7.8	2.39
	DF-250	0.10%	3.0	0.92
Total	**PAX**			**9.16**
	DF-250			**3.34**
	Pine Oil			**11.92**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,607			2.75
Ball Mill Discharge	1,644			
Screen Undersize	1,314			
Rougher Feed		8.42	17.2	
Pre-Cleaner Feed		8.43		
Cleaner Feed		8.43		
Scavenger Tail	1,329			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	199.9	1,314	6.8	12.4
Scavenger	168	197.5	1,322	6.5	25.8
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.38	1.36	0.35	1.46	195.8
Rod Mill Discharge			0.35	1.46	195.8
Ball Mill Discharge	0.17	0.92	0.16	0.83	308.5
Screen Feed	0.23	1.05	0.23	1.08	504.3
Screen Oversize	0.14	0.77	0.16	0.83	308.5
Screen Undersize	0.32	1.61	0.35	1.46	195.8
Rougher Feed	0.36	1.58	0.44	1.53	199.9
Rougher Conc	17.6	10.0	20.1	11.4	2.3
Rougher Tail	0.22	1.53	0.21	1.41	197.5
Scav Tail (final)	0.10	1.48	0.10	1.34	194.6
Scavenger Conc	8.26	5.84	6.99	6.26	5.7
Pre-Cleaner Feed	13.2	8.64	19.9	11.3	2.4
Pre-Cleaner Conc	38.6	20.0	38.0	19.2	1.2
Pre-Cleaner Tail	1.88	3.49	2.19	3.62	1.2
Cleaner Feed	1.81	3.70	2.19	3.62	1.2
Cleaner Conc	29.8	15.2	29.3	15.5	0.1
Cleaner Tail	0.72	3.06	0.97	3.08	1.2
Clnr-Scav Conc	8.44	7.66	7.50	8.01	0.1
Clnr-Scav Tail	0.51	2.97	0.46	2.62	1.1
Final Concentrate	37.6	19.5	37.7	19.0	1.3

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.00	0.35	1.46	100.0	100.0
Final Conc	0.64	37.7	19.0	70.1	8.4
Final Tail	99.36	0.10	1.34	29.9	91.6
Rougher Feed	102.06	0.44	1.53	131.0	106.9
Conc	1.20	20.1	11.40	69.8	9.4
Tail	100.86	0.21	1.41	61.2	97.5
Scavenger Feed	100.86	0.21	1.41	60.5	97.5
Conc	1.50	6.99	6.26	30.3	6.4
Tail	99.36	0.10	1.34	30.2	91.0
Pre-Cleaner Feed	1.24	19.9	11.33	71.6	9.6
Conc	0.61	38.0	19.2	67.7	8.1
Tail	0.63	2.19	3.62	3.9	1.6
Cleaner Feed	0.63	2.19	3.62	4.0	1.6
Conc	0.03	29.3	15.5	2.3	0.3
Tail	0.60	0.97	3.08	1.7	1.3
Clnr/Scav Feed	0.60	0.97	3.08	1.7	1.3
Conc	0.04	7.50	8.01	0.9	0.2
Tail	0.56	0.46	2.62	0.8	1.0
Cleaners Only Feed	1.24	19.9	11.33	71.6	9.6
Final Conc	0.64	37.7	19.0	70.1	8.4
Cleaner Tail	0.60	0.97	3.08	1.5	1.3

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.0	0.35	1.46	100.0	100.0
Final Conc	0.64	37.7	19.0	70.1	8.4
Final Tail	99.4	0.10	1.34	29.9	91.6
Rougher Feed	100.0	0.44	1.53	100.0	100.0
Conc	1.2	20.1	11.40	53.3	8.8
Tail	98.8	0.21	1.41	46.7	91.2
Scavenger Feed	100.0	0.21	1.41	100.0	100.0
Conc	1.5	6.99	6.26	50.2	6.6
Tail	98.5	0.10	1.34	49.8	93.4
Pre-Cleaner Feed	100.0	19.9	11.33	100.0	100.0
Conc	49.5	38.0	19.2	94.5	83.8
Tail	50.5	2.19	3.62	5.5	16.2
Cleaner Feed	100.0	2.19	3.62	100.0	100.0
Conc	4.31	29.3	15.5	57.7	18.5
Tail	95.7	0.97	3.08	42.3	81.5
Clnr/Scav Feed	100.0	0.97	3.08	100.0	100.0
Conc	6.83	7.50	8.01	52.7	17.8
Tail	93.2	0.46	2.62	47.3	82.2
Cleaners Only Feed	100.0	19.9	11.33	100.0	100.0
Final Conc	51.7	37.7	19.0	97.8	87.0
Cleaner Tail	48.3	0.97	3.08	2.2	13.0

5. Screen Analyses:

Detailed in the following pages.

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 157.5 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	3.8	0.0	7.7	6.4	4.7
14	11.7	0.0	14.5	8.3	9.1
20	15.0	0.0	18.8	11.0	11.3
28	13.0	0.6	22.1	13.7	13.8
35	10.3	7.6	15.9	13.4	12.7
48	7.3	9.6	7.8	9.6	9.2
65	6.8	10.8	4.3	8.4	7.5
100	6.0	11.6	2.6	6.3	6.1
150	4.7	9.7	1.4	4.7	4.9
200	3.9	9.1	1.0	3.8	4.0
270	3.5	8.3	0.8	3.0	3.5
400	2.3	6.4	0.5	2.2	2.8
Pan	11.7	26.4	2.6	9.1	10.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	3.8	0.0
14	190 %	9.5	18.0
20	191 %	12.4	23.6
28	149 %	13.5	20.0
35	110 %	11.9	13.1
48	126 %	8.6	10.8
65	98 %	7.6	7.4
100	154 %	6.2	9.5
150	152 %	4.7	7.2
200	180 %	3.9	6.9
270	217 %	3.2	6.8
400	237 %	2.2	5.3
Pan	228 %	12.6	28.8
Total	–	100.0	157.5 %

Test No. PP-8 LR-3897

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	56.5	13.7	13.7	86.3
6	3,327	62.3	15.2	28.9	71.1
8	2,362	51.1	12.4	41.3	58.7
10	1,651	40.0	9.7	51.1	48.9
14	1,168	34.0	8.3	59.3	40.7
20	833	26.2	6.4	65.7	34.3
28	589	22.3	5.4	71.1	28.9
35	417	18.8	4.6	75.7	24.3
48	295	14.0	3.4	79.1	20.9
65	208	13.2	3.2	82.3	17.7
100	147	12.9	3.1	85.5	14.5
150	104	10.6	2.6	88.1	11.9
200	74	9.9	2.4	90.5	9.5
270	53	9.1	2.2	92.7	7.3
400	37	5.9	1.4	94.1	5.9
Pan	-37	24.2	5.9	100.0	-
Total	-	**411.0**	**100.0**	-	-
K80	**4,145**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	9.7	3.8	3.8	96.2
14	1,168	29.5	11.7	15.5	84.5
20	833	37.9	15.0	30.5	69.5
28	589	33.0	13.0	43.5	56.5
35	417	26.2	10.3	53.8	46.2
48	295	18.6	7.3	61.2	38.8
65	208	17.1	6.8	67.9	32.1
100	147	15.2	6.0	73.9	26.1
150	104	12.0	4.7	78.7	21.3
200	74	10.0	3.9	82.6	17.4
270	53	8.8	3.5	86.1	13.9
400	37	5.7	2.3	88.3	11.7
Pan	-37	29.5	11.7	100.0	-
Total	-	**253.2**	**100.0**	-	-
K80	**1,065**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	10.9	4.7	4.7	95.3
14	1,168	20.9	9.1	13.8	86.2
20	833	26.2	11.3	25.1	74.9
28	589	31.9	13.8	38.9	61.1
35	417	29.4	12.7	51.7	48.3
48	295	21.3	9.2	60.9	39.1
65	208	17.4	7.5	68.4	31.6
100	147	14.0	6.1	74.5	25.5
150	104	11.3	4.9	79.4	20.6
200	74	9.3	4.0	83.4	16.6
270	53	8.1	3.5	86.9	13.1
400	37	6.4	2.8	89.7	10.3
Pan	-37	23.8	10.3	100.0	-
Total	-	**230.9**	**100.0**	-	-
K80	974				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	29.3	7.7	7.7	92.3
14	1,168	55.2	14.5	22.2	77.8
20	833	71.8	18.8	41.0	59.0
28	589	84.2	22.1	63.1	36.9
35	417	60.6	15.9	79.0	21.0
48	295	29.8	7.8	86.8	13.2
65	208	16.3	4.3	91.1	8.9
100	147	10.0	2.6	93.7	6.3
150	104	5.5	1.4	95.1	4.9
200	74	3.7	1.0	96.1	3.9
270	53	3.0	0.8	96.9	3.1
400	37	1.8	0.5	97.4	2.6
Pan	-37	10.1	2.6	100.0	-
Total	-	**381.3**	**100.0**	-	-
K80	1,240				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.3	0.2	0.2	99.8
35	417	5.2	3.9	4.1	95.9
48	295	10.2	7.7	11.8	88.2
65	208	14.3	10.8	22.6	77.4
100	147	15.5	11.7	34.2	65.8
150	104	14.1	10.6	44.8	55.2
200	74	12.9	9.7	54.5	45.5
270	53	11.8	8.9	63.4	36.6
400	37	9.1	6.8	70.2	29.8
Pan	-37	39.6	29.8	100.0	-
Total	-	**133.0**	**100.0**	-	-
K80	**227**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	0.9	3.5	3.5	96.5
100	147	0.4	1.6	5.1	94.9
150	104	0.4	1.6	6.6	93.4
200	74	0.7	2.7	9.4	90.6
270	53	1.2	4.7	14.1	85.9
400	37	1.1	4.3	18.4	81.6
Pan	-37	20.9	81.6	100.0	-
Total	-	**25.6**	**100.0**	-	-
K80	**~33**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	19.1	6.4	6.4	93.6
14	1,168	24.7	8.3	14.8	85.2
20	833	32.6	11.0	25.8	74.2
28	589	40.7	13.7	39.5	60.5
35	417	39.7	13.4	52.9	47.1
48	295	28.4	9.6	62.5	37.5
65	208	24.8	8.4	70.9	29.1
100	147	18.6	6.3	77.1	22.9
150	104	14.0	4.7	81.8	18.2
200	74	11.3	3.8	85.7	14.3
270	53	8.9	3.0	88.7	11.3
400	37	6.6	2.2	90.9	9.1
Pan	-37	27.0	9.1	100.0	-
Total	-	**296.4**	**100.0**	-	-
K80	**996**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.7	0.6	0.6	99.4
35	417	8.9	7.6	8.2	91.8
48	295	11.2	9.6	17.8	82.2
65	208	12.6	10.8	28.5	71.5
100	147	13.6	11.6	40.1	59.9
150	104	11.4	9.7	49.9	50.1
200	74	10.6	9.1	58.9	41.1
270	53	9.7	8.3	67.2	32.8
400	37	7.5	6.4	73.6	26.4
Pan	-37	30.9	26.4	100.0	-
Total	-	**117.1**	**100.0**	-	-
K80	**274**				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.1	0.3	0.3	99.7
100	147	0.1	0.3	0.6	99.4
150	104	0.3	0.9	1.5	98.5
200	74	1.1	3.2	4.7	95.3
270	53	1.6	4.7	9.4	90.6
400	37	1.9	5.6	15.0	85.0
Pan	-37	28.8	85.0	100.0	-
Total	-	33.9	100.0	-	-
K80	~25				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.2	1.1	1.1	98.9
100	147	3.9	3.7	4.8	95.2
150	104	7.9	7.4	12.2	87.8
200	74	12.5	11.7	23.9	76.1
270	53	14.6	13.7	37.6	62.4
400	37	10.4	9.7	47.3	52.7
Pan	-37	56.2	52.7	100.0	-
Total	-	106.7	100.0	-	-
K80	84.6				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.8	1.0	1.0	99.0
35	417	12.8	7.3	8.3	91.7
48	295	18.1	10.3	18.6	81.4
65	208	19.4	11.1	29.7	70.3
100	147	22.6	12.9	42.6	57.4
150	104	18.3	10.4	53.0	47.0
200	74	15.5	8.8	61.9	38.1
270	53	13.3	7.6	69.4	30.6
400	37	9.5	5.4	74.9	25.1
Pan	-37	44.1	25.1	100.0	-
Total	-	175.4	100.0	-	-
K80	282				

1. **Purpose:** To duplicate the conditions of test PP-8.

2. **Procedure:** No changes in flowsheet from test PP-8.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	46.8 % -100 mesh
Copper Head Grade	0.33 % Cu
Final Tails Grade	0.12 % Cu
Final Copper Grade	38.9 % Cu
Final Copper Recovery	64.5 %

The operating problems in the grinding circuit were not improved in this test. Circulating load rose to 780% and the flotation feed size was significantly coarser at 47% -100 mesh.
The tails grade, at 0.11% Cu, was slightly higher than in the previous test, and recovery was accordingly lower. Although concentrate grade was maintained at +38% Cu, the recovery was only 66%.
This is the final planned test for the first part of the Phase One program. The succeeding tests will incorporate a unit column flotation cell in the grinding circuit. If higher collector dosages are used and recovery gains are realized, then one or two no-column tests may be run at the end of the program, in order to provide a basis for comparison.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed: 204.8 kg/h -1/4 inch (Wet Sple 1283.2 g)
(Dry Sple 1253.4 g)
Feed Rate: 200.0 kg/h dry ore (Moisture 2.32 %)
Mill Speed: 45 RPM (85% of critical speed)
Rod Load: 100 kg
Rod Mill Feed: Total 1,468 kg in 7.17 hr
Sample 512 kg in 2.50 hr
Rod Mill Discharge: 1,590 g/L (59 % Sol at SG 2.71)
57.1 % plus 48 mesh
29.6 % minus 100 mesh
Input Power: 41.12 for 3 disc revolutions
0.95 kW (95% drive efficiency)
Average Power: 0.90 kW Gross
0.47 kW No Load
0.42 kW Net
Net Power Usage: 2.12 kWh/t of -1/4 inch feed
K80 Feed: 3,925 microns
K80 Product: 990 microns
Work Index (metric): 13.4

3.1.2. Ball Mill Report:

Feed: Screen Oversize (at 346 % circ. load)
Feed Rate: 692.3 kg/h
Mill Speed: 40 RPM (77% of critical speed)
Ball Load: 150 kg
Screen Undersize: 1,228 g/L (29 % Sol at SG 2.71)
Ball Mill Discharge: 1,624 g/L (61 % Sol at SG 2.71)
83.2 % plus 48 mesh
8.8 % minus 100 mesh
Input Power: 34.60 for 3 disc revolutions
1.12 kW (95% drive efficiency)
Average Power: 1.07 kW Gross
0.52 kW No Load
0.54 kW Net
Net Power Usage: 0.79 kWh/t of screen oversize
K80 Feed: 990 microns
K80 Product: 434 microns
Work Index (metric): 4.9

3.1.3. Overall Mill Report:

Net Power Usage:	2.91 kWh/t
K80 Feed:	3,925 microns
K80 Product:	434 microns
Work Index (metric):	9.1
Screen Undersize:	46.8 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	3,925	15.7
Rod Mill Discharge	990	29.6
Screen Feed	1,096	15.9
Ball Mill Feed	1,233	4.7
Ball Mill Discharge	1,140	8.8
Screen Undersize	434	46.8
Rougher Feed	310	59.5
Regrind Feed	~25	96.3
Regrind Discharge	~20	99.2
Final Concentrate	106.1	91.5
Final Tail	355	51.3

3.2. Reagent Additions:

Average Feed Rate: 0.200 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	PAX	0.10%	12.0	3.60
	DF-250	0.10%	4.3	1.29
	Pine Oil	100%	4.0 dr	10.80
Scavenger Feed	PAX	0.10%	12.1	3.63
	DF-250	0.10%	4.0	1.20
	Pine Oil	0.10%	2.2	0.66
Scavenger Cell 4	PAX	0.10%	8.1	2.43
	DF-250	0.10%	2.8	0.84
Total	**PAX**			**9.66**
	DF-250			**3.33**
	Pine Oil			**11.46**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,590			2.71
Ball Mill Discharge	1,624			
Screen Undersize	1,228			
Rougher Feed		8.53	14.9	
Pre-Cleaner Feed		8.51		
Cleaner Feed		8.49		
Scavenger Tail	1,246			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	220.6	1,228	10.3	8.2
Scavenger	168	216.6	1,237	9.7	17.3
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.34	1.45	0.33	1.60	200.0
Rod Mill Discharge			0.33	1.60	200.0
Ball Mill Discharge	0.11	0.78	0.13	0.86	692.3
Screen Feed	0.19	1.16	0.17	1.02	892.4
Screen Oversize	0.13	0.82	0.17	0.86	692.3
Screen Undersize	0.32	1.78	0.33	1.60	200.0
Rougher Feed	0.47	1.76	0.53	1.80	220.6
Rougher Conc	11.4	7.6	11.2	7.34	4.1
Rougher Tail	0.30	2.05	0.33	1.69	216.6
Scav Tail (final)	0.11	1.47	0.12	1.50	198.9
Scavenger Conc	4.10	3.64	2.64	3.86	17.6
Pre-Cleaner Feed	9.6	6.86	9.60	6.93	5.0
Pre-Cleaner Conc	39.3	20.2	39.1	19.6	1.0
Pre-Cleaner Tail	2.31	3.77	2.31	3.81	4.0
Cleaner Feed	2.20	3.85	2.31	3.81	4.0
Cleaner Conc	37.1	18.8	36.9	18.5	0.1
Cleaner Tail	1.45	3.55	1.46	3.45	3.9
Clnr-Scav Conc	14.90	9.57	2.79	5.20	1.0
Clnr-Scav Tail	1.05	3.25	1.03	2.87	3.0
Final Concentrate	38.7	19.3	38.9	19.5	1.1

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays Cu	Assays Fe	Distributions (%) Cu	Distributions (%) Fe
New Feed	100.00	0.33	1.60	100.0	100.0
Final Conc	0.55	38.9	19.5	64.5	6.7
Final Tail	99.45	0.121	1.50	35.5	93.3
Rougher Feed	110.30	0.53	1.80	176.1	123.9
Conc	2.03	11.2	7.34	69.1	9.3
Tail	108.27	0.33	1.69	107.0	114.6
Scavenger Feed	108.27	0.33	1.69	107.0	114.6
Conc	8.81	2.64	3.86	70.6	21.3
Tail	99.45	0.121	1.50	36.4	93.4
Combined Clnr Feed	2.03	11.2	7.34	69.1	9.3
Final Conc	0.55	38.9	19.5	64.5	6.7
Clnr/Scav Tail	1.48	1.03	2.87	4.6	2.7
Pre-Cleaner Feed	2.52	9.6	6.93	73.2	10.9
Conc	0.50	39.1	19.6	59.1	6.1
Tail	2.02	2.31	3.81	14.1	4.8
Cleaner Feed	2.02	2.31	3.81	14.1	4.8
Conc	0.05	36.9	18.5	5.4	0.6
Tail	1.97	1.46	3.45	8.7	4.2
Clnr/Scav Feed	1.97	1.46	3.45	8.7	4.2
Conc	0.49	2.79	5.20	4.1	1.6
Tail	1.48	1.03	2.87	4.6	2.7
Cleaners Only Feed	2.52	9.6	6.93	73.2	10.9
Final Conc	0.55	38.9	19.5	64.5	6.7
Cleaner Tail	1.97	1.46	3.45	8.7	4.2

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.0	0.33	1.60	100.0	100.0
Final Conc	0.55	38.9	19.5	64.5	6.7
Final Tail	99.5	0.121	1.50	35.5	93.3
Rougher Feed	100.0	0.53	1.80	100.0	100.0
Conc	1.8	11.2	7.34	39.2	7.5
Tail	98.2	0.33	1.69	60.8	92.5
Scavenger Feed	100.0	0.33	1.69	100.0	100.0
Conc	8.1	2.64	3.86	66.0	18.6
Tail	91.9	0.121	1.50	34.0	81.4
Combined Clnr Feed	100.0	11.2	7.34	100.0	100.0
Final Conc	26.9	38.9	19.5	93.3	71.5
Clnr/Scav Tail	73.1	1.03	2.87	6.7	28.5
Pre-Cleaner Feed	100.0	9.6	6.93	100.0	100.0
Conc	19.8	39.1	19.6	80.8	56.0
Tail	80.2	2.31	3.81	19.2	44.0
Cleaner Feed	100.0	2.31	3.81	100.0	100.0
Conc	2.38	36.9	18.5	38.1	11.6
Tail	97.6	1.46	3.45	61.9	88.4
Clnr/Scav Feed	100.0	1.46	3.45	100.0	100.0
Conc	24.77	2.79	5.20	47.3	37.4
Tail	75.2	1.03	2.87	52.7	62.6
Cleaners Only Feed	100.0	9.6	6.93	100.0	100.0
Final Conc	21.7	38.9	19.5	88.1	61.1
Cleaner Tail	78.3	1.46	3.45	11.9	38.9

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	64.8	12.1	12.1	87.9
6	3,327	76.7	14.3	26.3	73.7
8	2,362	66.0	12.3	38.6	61.4
10	1,651	56.1	10.4	49.0	51.0
14	1,168	48.5	9.0	58.0	42.0
20	833	35.0	6.5	64.6	35.4
28	589	30.0	5.6	70.1	29.9
35	417	24.5	4.6	74.7	25.3
48	295	18.4	3.4	78.1	21.9
65	208	18.2	3.4	81.5	18.5
100	147	15.3	2.8	84.3	15.7
150	104	13.2	2.5	86.8	13.2
200	74	12.3	2.3	89.1	10.9
270	53	11.0	2.0	91.1	8.9
400	37	8.6	1.6	92.7	7.3
Pan	-37	39.1	7.3	100.0	-
Total	-	**537.7**	**100.0**	-	-
K80	**3,925**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	7.8	2.9	2.9	97.1
14	1,168	25.7	9.7	12.7	87.3
20	833	37.2	14.0	26.7	73.3
28	589	33.7	12.7	39.4	60.6
35	417	27.2	10.3	49.7	50.3
48	295	19.5	7.4	57.1	42.9
65	208	19.5	7.4	64.4	35.6
100	147	15.8	6.0	70.4	29.6
150	104	13.4	5.1	75.5	24.5
200	74	11.5	4.3	79.8	20.2
270	53	9.7	3.7	83.5	16.5
400	37	7.5	2.8	86.3	13.7
Pan	-37	36.3	13.7	100.0	-
Total	-	**264.8**	**100.0**	-	-
K80	**990**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	14.4	5.4	5.4	94.6
14	1,168	30.6	11.4	16.7	83.3
20	833	46.2	17.2	33.9	66.1
28	589	53.9	20.1	54.0	46.0
35	417	36.2	13.5	67.4	32.6
48	295	19.4	7.2	74.7	25.3
65	208	14.8	5.5	80.2	19.8
100	147	10.6	3.9	84.1	15.9
150	104	7.8	2.9	87.0	13.0
200	74	6.1	2.3	89.3	10.7
270	53	5.0	1.9	91.1	8.9
400	37	3.9	1.5	92.6	7.4
Pan	-37	19.9	7.4	100.0	-
Total	-	**268.8**	**100.0**	-	-
K80	**1,096**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	19.7	6.2	6.2	93.8
14	1,168	48.0	15.2	21.4	78.6
20	833	74.3	23.5	44.9	55.1
28	589	87.4	27.6	72.5	27.5
35	417	43.9	13.9	86.3	13.7
48	295	16.6	5.2	91.6	8.4
65	208	8.1	2.6	94.1	5.9
100	147	3.7	1.2	95.3	4.7
150	104	2.2	0.7	96.0	4.0
200	74	1.6	0.5	96.5	3.5
270	53	1.1	0.3	96.8	3.2
400	37	0.6	0.2	97.0	3.0
Pan	-37	9.4	3.0	100.0	-
Total	-	316.6	**100.0**	-	-
K80	**1,233**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	22.8	7.2	7.2	92.8
14	1,168	38.2	12.0	19.2	80.8
20	833	59.2	18.6	37.8	62.2
28	589	73.9	23.2	61.1	38.9
35	417	47.4	14.9	76.0	24.0
48	295	23.1	7.3	83.2	16.8
65	208	15.7	4.9	88.2	11.8
100	147	9.7	3.1	91.2	8.8
150	104	5.8	1.8	93.0	7.0
200	74	4.2	1.3	94.4	5.6
270	53	3.2	1.0	95.4	4.6
400	37	2.0	0.6	96.0	4.0
Pan	-37	12.7	4.0	100.0	-
Total	-	**317.9**	**100.0**	-	-
K80	**1,140**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	6.0	3.3	3.3	96.7
35	417	32.8	18.0	21.3	78.7
48	295	21.5	11.8	33.2	66.8
65	208	15.8	8.7	41.8	58.2
100	147	20.7	11.4	53.2	46.8
150	104	14.8	8.1	61.4	38.6
200	74	12.3	6.8	68.1	31.9
270	53	10.7	5.9	74.0	26.0
400	37	7.5	4.1	78.1	21.9
Pan	-37	39.8	21.9	100.0	-
Total	-	**181.9**	**100.0**	-	-
K80	**434**				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.3	0.8	0.8	99.2
150	104	0.5	1.3	2.2	97.8
200	74	0.8	2.2	4.3	95.7
270	53	1.3	3.5	7.8	92.2
400	37	1.7	4.6	12.4	87.6
Pan	-37	32.6	87.6	100.0	-
Total	-	**37.2**	**100.0**	-	-
K80	~26				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.0	1.9	1.9	98.1
100	147	10.5	6.6	8.5	91.5
150	104	18.5	11.7	20.2	79.8
200	74	22.4	14.1	34.3	65.7
270	53	20.9	13.2	47.5	52.5
400	37	17.3	10.9	58.5	41.5
Pan	-37	65.8	41.5	100.0	-
Total	-	**158.4**	**100.0**	-	-
K80	**106.1**				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	2.7	1.6	1.6	98.4
35	417	22.3	13.0	14.5	85.5
48	295	20.5	11.9	26.5	73.5
65	208	17.9	10.4	36.9	63.1
100	147	20.3	11.8	48.7	51.3
150	104	15.1	8.8	57.5	42.5
200	74	12.3	7.2	64.6	35.4
270	53	10.9	6.3	71.0	29.0
400	37	7.6	4.4	75.4	24.6
Pan	-37	42.3	24.6	100.0	-
Total	-	**171.9**	**100.0**	-	-
K80	355				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	3.0	1.5	1.5	98.5
35	417	21.4	10.6	12.1	87.9
48	295	20.5	10.1	22.2	77.8
65	208	15.4	7.6	29.8	70.2
100	147	21.7	10.7	40.5	59.5
150	104	17.2	8.5	49.0	51.0
200	74	15.8	7.8	56.8	43.2
270	53	14.6	7.2	64.1	35.9
400	37	10.8	5.3	69.4	30.6
Pan	-37	61.9	30.6	100.0	-
Total	-	**202.3**	**100.0**	-	-
K80	**310**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	0.9	2.8	2.8	97.2
100	147	0.3	0.9	3.7	96.3
150	104	0.2	0.6	4.3	95.7
200	74	0.6	1.9	6.2	93.8
270	53	1.1	3.4	9.6	90.4
400	37	1.2	3.7	13.3	86.7
Pan	-37	28.0	86.7	100.0	-
Total	-	**32.3**	**100.0**	-	-
K80	**~25**				

Test No. PP-9

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 358.0 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	2.9	0.0	6.2	7.2	5.4
14	9.7	0.0	15.2	12.0	11.4
20	14.0	0.0	23.5	18.6	17.2
28	12.7	3.3	27.6	23.2	20.1
35	10.3	18.0	13.9	14.9	13.5
48	7.4	11.8	5.2	7.3	7.2
65	7.4	8.7	2.6	4.9	5.5
100	6.0	11.4	1.2	3.1	3.9
150	5.1	8.1	0.7	1.8	2.9
200	4.3	6.8	0.5	1.3	2.3
270	3.7	5.9	0.3	1.0	1.9
400	2.8	4.1	0.2	0.6	1.5
Pan	13.7	21.9	3.0	4.0	7.4
Total	100.0	100.0	100.0	100.0	100.0

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	2.9	0.0
14	309 %	11.5	35.3
20	290 %	17.4	50.6
28	216 %	19.9	43.1
35	743 %	14.4	106.7
48	220 %	7.3	16.1
65	56 %	6.5	3.6
100	288 %	3.8	10.9
150	272 %	2.7	7.3
200	297 %	2.1	6.2
270	337 %	1.6	5.4
400	294 %	1.2	3.5
Pan	797 %	8.7	69.3
Total	–	100.0	358.0 %

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** A 150 mm glass column flotation cell was inserted into the grinding circuit in the screen feed pipeline.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:** Numerous pumping problems were encountered in this first attempt to operate a pilot scale column flotation cell on -4 mesh feed. The operating shift was spent identifying pumping problems and determining suitable remedies.

A major system plug-up occurred immediately prior to the intended sampling period, and it was decided to abandon the sampling period for this test.

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	35.9 % -100 mesh
Rod Mill Feed Grade	0.41 % Cu
Column Conc Grade	41.4 % Cu
Column Copper Rec'y	12.1 %
Flotation Feed Size	57.1 % -100 mesh
Flotation Head Grade	0.36 % Cu
Final Tails Grade	0.19 % Cu
Flotation Copper Grade	41.9 % Cu
Flotation Copper Rec'y	54.2 %
Combined Grade	41.8 % Cu
Combined Recovery	66.3 %

The first full successful operating shift with the unit column in the circuit showed that the column was able to recover copper at very high grade in the single pass process, without benefit of regrinding or multiple cleaning stages.

The froth, as expected, was very sparse, and it proved necessary to operate the column with a relatively shallow (for columns) froth depth of only 10 to 15 cm. It was also necessary to limit the flow of wash water to the column, in order to avoid excessive froth breakage. It was relatively easy to destroy the froth column with excess wash water.

The conventional circuit also performed very well, and produced a higher concentrate grade than the unit column.

3.1.3. Overall Mill Report:

Net Power Usage:	6.89 kWh/t
K80 Feed:	4,018 microns
K80 Product:	289 microns
Work Index (metric):	16.0
Screen Undersize:	57.1 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,018	15.7
Rod Mill Discharge	1,028	27.3
Column Feed	827	35.9
Column Conc	68	84.1
Column Tail	802	36.4
Ball Mill Feed	1,269	5.3
Ball Mill Discharge	143	80.6
Screen Undersize	289	46.8
Rougher Feed	248	64.3
Regrind Feed	~25	97.0
Regrind Discharge	~20	99.6
Final Concentrate	118.5	97.0
Final Tail	280	57.8

3.2. Reagent Additions:

Average Feed Rate: 0.193 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	1.0	0.31
	DF-250	0.10%	7.0	2.17
	Pine Oil	100%	4.0 dr	11.17
Rougher Feed	PAX	0.10%	5.0	1.55
Scavenger Feed	PAX	0.10%	12.0	3.72
	DF-250	0.10%	2.0	0.62
	Pine Oil	0.10%	2.0	0.62
Scavenger Cell 4	PAX	0.10%	8.0	2.48
	DF-250	0.10%	4.0	1.24
Total	**PAX**			**8.07**
	DF-250			**4.03**
	Pine Oil			**11.79**

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	198.1 kg/h	-1/4 inch	(Wet Sple 1594.2 g)
			(Dry Sple 1556.5 g)
Feed Rate:	193.4 kg/h	dry ore	(Moisture 2.36 %)
Mill Speed:	45 RPM	(85% of critical speed)	
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,288 kg in 6.50 hr	
	Sample	594 kg in 3.00 hr	
Rod Mill Discharge:	1,616 g/L	(60 % Sol at SG 2.74)	
	59.7	% plus 48 mesh	
	27.3	% minus 100 mesh	
Input Power:	42.72	for 3 disc revolutions	
	0.91	kW (95% drive efficiency)	
Average Power:	0.86 kW	Gross	
	0.47 kW	No Load	
	0.39 kW	Net	
Net Power Usage:	2.02 kWh/t	of -1/4 inch feed	
K80 Feed:	4,018	microns	
K80 Product:	1,028	microns	
Work Index (metric):	13.1		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 58 % circ. load)
Feed Rate:	111.8 kg/h		
Mill Speed:	40 RPM	(77% of critical speed)	
Ball Load:	150 kg		
Screen Undersize:	1,134 g/L	(19 % Sol at SG 2.74)	
Ball Mill Discharge:	1,621 g/L	(60 % Sol at SG 2.74)	
	7.5	% plus 48 mesh	
	80.6	% minus 100 mesh	
Input Power:	34.60	for 3 disc revolutions	
	1.12	kW (95% drive efficiency)	
Average Power:	1.07 kW	Gross	
	0.52 kW	No Load	
	0.54 kW	Net	
Net Power Usage:	4.87 kWh/t	of screen oversize	
K80 Feed:	1,028	microns	
K80 Product:	289	microns	
Work Index (metric):	17.6		

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,616			2.74
Ball Mill Discharge	1,621			
Screen Feed	1,233			
Screen Undersize	1,134			
Rougher Feed		8.00	10.0	
Pre-Cleaner Feed		8.00		
Cleaner Feed		8.00		
Scavenger Tail	1,173			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	305.3	1,233	13.9	2.9
Rougher	84	198.1	1,134	15.6	5.4
Scavenger	168	196.3	1,154	13.5	12.4
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results: (58% circulating load)

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.46	1.54	0.41	1.52	193.4
Rod Mill Discharge			0.41	1.52	193.4
Ball Mill Discharge	0.26	1.26	0.26	1.24	111.8
Column Feed	0.32	1.35	0.35	1.42	305.3
Column Conc	40.70	19.10	41.4	19.0	0.23
Column Tail (Scr Fd)	0.36	1.41	0.32	1.41	305.0
Screen Oversize	0.21	0.95	0.26	1.24	111.7
Screen Undersize	0.33	1.52	0.36	1.50	193.2
Rougher Feed	0.38	1.70	0.51	1.61	198.1
Rougher Conc	23.4	13.4	23.5	13.4	1.87
Rougher Tail	0.26	1.36	0.29	1.50	196.3
Scav Tail (final)	0.13	1.38	0.19	1.42	192.2
Scavenger Conc	5.57	5.13	4.92	5.13	4.09
Pre-Cleaner Feed	15.7	9.78	16.7	10.8	2.79
Pre-Cleaner Conc	42.0	21.7	42.8	21.3	0.94
Pre-Cleaner Tail	3.29	4.66	3.46	5.49	1.85
Cleaner Feed	3.47	5.49	3.46	5.49	1.85
Cleaner Conc	31.1	17.6	31.1	17.5	0.08
Cleaner Tail	2.16	4.74	2.22	4.95	1.77
Clnr-Scav Conc	12.60	10.30	2.81	5.57	0.92
Clnr-Scav Tail	1.60	4.47	1.58	4.28	0.85
Flotation Conc	41.0	21.1	41.9	21.0	1.02
Combined Conc			41.8	20.6	1.25

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.00	0.41	1.52	100.0	100.0
Combined Conc	0.65	41.8	20.6	66.3	8.7
Final Tail	99.35	0.187	1.42	33.7	91.3
Column Feed	157.83	0.35	1.42	136.9	147.1
Conc	0.12	41.4	19.0	12.1	1.5
Tail	157.71	0.32	1.41	124.8	145.6
Flotation Feed	99.88	0.36	1.50	87.9	98.5
Conc	0.53	41.9	21.0	54.2	7.3
Tail	99.36	0.19	1.42	33.7	91.2
Rougher Feed	102.44	0.51	1.61	127.1	108.2
Conc	0.97	23.5	13.39	56.0	8.5
Tail	101.47	0.29	1.50	71.1	99.7
Scavenger Feed	101.47	0.29	1.50	71.3	99.7
Conc	2.11	4.92	5.13	25.5	7.1
Tail	99.36	0.187	1.42	45.8	92.6
Combined Clnr Feed	0.97	23.5	13.39	56.0	8.5
Flotation Conc	0.53	41.9	21.0	54.2	7.3
Clnr/Scav Tail	0.44	1.58	4.28	1.8	1.2
Pre-Cleaner Feed	1.44	16.7	10.82	59.2	10.2
Conc	0.49	42.8	21.3	51.1	6.8
Tail	0.96	3.46	5.49	8.2	3.4
Cleaner Feed	0.96	3.46	5.49	8.1	3.4
Conc	0.04	31.1	17.5	3.1	0.5
Tail	0.92	2.22	4.95	5.0	3.0
Clnr/Scav Feed	0.92	2.22	4.95	5.0	3.0
Conc	0.48	2.81	5.57	3.3	1.7
Tail	0.44	1.58	4.28	1.7	1.2

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.41	1.52	100.0	100.0
Combined Conc	0.65	41.8	20.6	66.3	8.7
Final Tail	99.4	0.187	1.42	33.7	91.3
Column Feed	100.0	0.35	1.42	100.0	100.0
Conc	0.08	41.4	19.0	8.8	1.0
Tail	99.9	0.32	1.41	91.2	99.0
Flotation Feed	100.0	0.36	1.50	100.0	100.0
Conc	0.53	41.9	21.0	61.7	7.4
Tail	99.5	0.19	1.42	38.3	92.6
Rougher Feed	100.0	0.51	1.61	100.0	100.0
Conc	0.94	23.5	13.4	44.0	7.9
Tail	99.1	0.29	1.50	56.0	92.1
Scavenger Feed	100.0	0.29	1.50	100.0	100.0
Conc	2.1	4.92	5.13	35.8	7.1
Tail	97.9	0.187	1.42	64.2	92.9
Combined Clnr Feed	100.0	23.5	13.4	100.0	100.0
Flotation Conc	54.4	41.9	21.0	96.9	85.4
Clnr/Scav Tail	45.6	1.58	4.28	3.1	14.6
Pre-Cleaner Feed	100.0	16.7	10.82	100.0	100.0
Conc	33.7	42.8	21.3	86.2	66.3
Tail	66.3	3.46	5.49	13.8	33.7
Cleaner Feed	100.0	3.46	5.49	100.0	100.0
Conc	4.28	31.1	17.5	38.6	13.7
Tail	95.7	2.22	4.95	61.4	86.3
Clnr/Scav Feed	100.0	2.22	4.95	100.0	100.0
Conc	51.9	2.81	5.57	65.7	58.4
Tail	48.1	1.58	4.28	34.3	41.6

5. Screen Analyses: Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	65.4	12.4	12.4	87.6
6	3,327	81.1	15.4	27.9	72.1
8	2,362	63.1	12.0	39.8	60.2
10	1,651	48.2	9.2	49.0	51.0
14	1,168	44.6	8.5	57.5	42.5
20	833	32.7	6.2	63.7	36.3
28	589	29.0	5.5	69.2	30.8
35	417	24.8	4.7	73.9	26.1
48	295	19.5	3.7	77.6	22.4
65	208	19.1	3.6	81.3	18.7
100	147	15.7	3.0	84.3	15.7
150	104	13.5	2.6	86.8	13.2
200	74	12.4	2.4	89.2	10.8
270	53	10.8	2.1	91.2	8.8
400	37	8.1	1.5	92.8	7.2
Pan	-37	38.0	7.2	100.0	-
Total	-	**526.0**	**100.0**	-	-
K80	**4,057**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.6	3.5	3.5	96.5
14	1,168	19.7	10.6	14.1	85.9
20	833	26.9	14.4	28.5	71.5
28	589	24.7	13.3	41.8	58.2
35	417	19.5	10.5	52.3	47.7
48	295	13.9	7.5	59.7	40.3
65	208	12.8	6.9	66.6	33.4
100	147	11.5	6.2	72.7	27.3
150	104	9.1	4.9	77.6	22.4
200	74	7.8	4.2	81.8	18.2
270	53	6.9	3.7	85.5	14.5
400	37	4.5	2.4	87.9	12.1
Pan	-37	22.5	12.1	100.0	-
Total	-	**186.4**	**100.0**	-	-
K80	**1,028**				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.7	2.3	2.3	97.7
14	1,168	21.5	7.3	9.5	90.5
20	833	30.6	10.3	19.8	80.2
28	589	30.3	10.2	30.1	69.9
35	417	28.0	9.4	39.5	60.5
48	295	24.2	8.2	47.7	52.3
65	208	26.0	8.8	56.4	43.6
100	147	22.7	7.7	64.1	35.9
150	104	19.4	6.5	70.6	29.4
200	74	15.9	5.4	76.0	24.0
270	53	11.8	4.0	80.0	20.0
400	37	7.4	2.5	82.5	17.5
Pan	-37	52.0	17.5	100.0	-
Total	-	**296.5**	**100.0**	-	-
K80	**827**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.5	0.9	0.9	99.1
100	147	3.2	1.8	2.7	97.3
150	104	7.6	4.3	7.0	93.0
200	74	15.5	8.9	15.9	84.1
270	53	28.3	16.2	32.1	67.9
400	37	32.2	18.4	50.5	49.5
Pan	-37	86.5	49.5	100.0	-
Total	-	**174.8**	**100.0**	-	-
K80	**67.9**				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.1	2.0	2.0	98.0
14	1,168	21.3	6.9	8.9	91.1
20	833	30.8	10.0	18.8	81.2
28	589	32.1	10.4	29.2	70.8
35	417	30.2	9.8	39.0	61.0
48	295	25.4	8.2	47.2	52.8
65	208	26.0	8.4	55.6	44.4
100	147	24.8	8.0	63.6	36.4
150	104	19.9	6.4	70.1	29.9
200	74	16.3	5.3	75.3	24.7
270	53	14.2	4.6	79.9	20.1
400	37	8.7	2.8	82.7	17.3
Pan	-37	53.4	17.3	100.0	-
Total	-	309.2	100.0	-	-
K80	802				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	21.5	5.3	5.3	94.7
14	1,168	74.4	18.5	23.8	76.2
20	833	97.9	24.3	48.1	51.9
28	589	97.1	24.1	72.2	27.8
35	417	51.8	12.9	85.0	15.0
48	295	21.4	5.3	90.3	9.7
65	208	10.8	2.7	93.0	7.0
100	147	6.8	1.7	94.7	5.3
150	104	4.0	1.0	95.7	4.3
200	74	2.9	0.7	96.4	3.6
270	53	2.4	0.6	97.0	3.0
400	37	1.4	0.3	97.3	2.7
Pan	-37	10.7	2.7	100.0	-
Total	-	403.1	100.0	-	-
K80	1,269				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.0	0.0	0.0	100.0
20	833	0.0	0.0	0.0	100.0
28	589	4.0	2.4	2.4	97.6
35	417	3.5	2.1	4.4	95.6
48	295	5.3	3.1	7.5	92.5
65	208	6.1	3.6	11.1	88.9
100	147	14.1	8.3	19.4	80.6
150	104	17.3	10.2	29.6	70.4
200	74	20.8	12.2	41.8	58.2
270	53	21.1	12.4	54.2	45.8
400	37	15.6	9.2	63.4	36.6
Pan	-37	62.3	36.6	100.0	-
Total	-	**170.1**	**100.0**	-	-
K80	**143**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	2.0	1.8	1.8	98.2
35	417	6.0	5.5	7.3	92.7
48	295	14.3	13.1	20.4	79.6
65	208	10.5	9.6	30.0	70.0
100	147	14.1	12.9	42.9	57.1
150	104	11.3	10.3	53.2	46.8
200	74	10.0	9.1	62.3	37.7
270	53	9.0	8.2	70.6	29.4
400	37	6.2	5.7	76.2	23.8
Pan	-37	26.0	23.8	100.0	-
Total	-	**109.4**	**100.0**	-	-
K80	**289**				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.7	0.5	0.5	99.5
35	417	8.0	5.3	5.8	94.2
48	295	15.5	10.3	16.1	83.9
65	208	11.3	7.5	23.6	76.4
100	147	18.1	12.0	35.7	64.3
150	104	16.7	11.1	46.8	53.2
200	74	15.1	10.0	56.8	43.2
270	53	13.1	8.7	65.5	34.5
400	37	9.4	6.3	71.8	28.2
Pan	-37	42.4	28.2	100.0	-
Total	-	**150.3**	**100.0**	-	-
K80	**248**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	0.2	0.8	0.8	99.2
100	147	0.6	2.3	3.0	97.0
150	104	0.5	1.9	4.9	95.1
200	74	0.8	3.0	7.9	92.1
270	53	1.1	4.2	12.1	87.9
400	37	0.9	3.4	15.5	84.5
Pan	-37	22.4	84.5	100.0	-
Total	-	**26.5**	**100.0**	-	-
K80					

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.1	0.4	0.4	99.6
150	104	0.2	0.7	1.1	98.9
200	74	0.3	1.1	2.2	97.8
270	53	0.8	2.9	5.1	94.9
400	37	0.9	3.3	8.4	91.6
Pan	-37	25.0	91.6	100.0	-
Total	-	27.3	100.0	-	-
K80					

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	4.5	2.8	2.8	97.2
100	147	13.1	8.0	10.8	89.2
150	104	23.4	14.4	25.2	74.8
200	74	27.8	17.1	42.2	57.8
270	53	23.6	14.5	56.7	43.3
400	37	16.8	10.3	67.0	33.0
Pan	-37	53.7	33.0	100.0	-
Total	-	162.9	100.0	-	-
K80	119				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.7	0.4	0.4	99.6
35	417	12.2	7.0	7.4	92.6
48	295	18.9	10.8	18.2	81.8
65	208	21.0	12.0	30.2	69.8
100	147	20.9	12.0	42.2	57.8
150	104	17.9	10.2	52.4	47.6
200	74	15.5	8.9	61.3	38.7
270	53	13.1	7.5	68.8	31.2
400	37	10.3	5.9	74.7	25.3
Pan	-37	44.3	25.3	100.0	-
Total	-	174.8	100.0	-	-
K80	280				

Test No. PP-11

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 57.9 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	3.5	0.0	5.3	0.0	2.3
14	10.6	0.0	18.5	0.0	7.3
20	14.4	0.0	24.3	0.0	10.3
28	13.3	1.8	24.1	2.4	10.2
35	10.5	5.5	12.9	2.1	9.4
48	7.5	13.1	5.3	3.1	8.2
65	6.9	9.6	2.7	3.6	8.8
100	6.2	12.9	1.7	8.3	7.7
150	4.9	10.3	1.0	10.2	6.5
200	4.2	9.1	0.7	12.2	5.4
270	3.7	8.2	0.6	12.4	4.0
400	2.4	5.7	0.3	9.2	4.0
Pan	12.1	23.8	2.7	36.6	16.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	3.5	0.0
14	57 %	6.7	3.8
20	59 %	9.1	5.4
28	53 %	9.5	5.0
35	46 %	7.8	3.6
48	-256 %	0.3	-0.9
65	301 %	4.4	13.3
100	102 %	7.2	7.4
150	59 %	6.9	4.1
200	43 %	6.6	2.8
270	38 %	6.1	2.3
400	37 %	4.2	1.6
Pan	34 %	27.6	9.5
Total	**--**	**100.0**	**57.9 %**

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:** The circuit operated smoothly and the normal sampling procedure was set up for sampling from 2:00 PM to 4:00 PM.

At 1:30 PM, however, a major sanding of the column cell and the column tails pump occurred, and there was insufficient time remaining to restart the circuit and collect acceptable samples.

The sampling run was therefore abandoned.

Test No. PP-13

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	39.3 % -100 mesh
Rod Mill Feed Grade	0.41 % Cu
Column Conc Grade	42.7 % Cu
Column Copper Rec'y	17.5 %
Flotation Feed Size	55.6 % -100 mesh
Flotation Head Grade	0.34 % Cu
Final Tails Grade	0.15 % Cu
Flotation Copper Grade	39.9 % Cu
Flotation Copper Rec'y	46.3 %
Combined Grade	41.6 % Cu
Combined Recovery	65.4 %

Collector (PAX) dosage to the un it column was increased from 0.3 to 3 g/t, and Pine Oil was increased from 11 to 14 g/t, both in an effort to increase the recovery of copper in the unit column. Metallurgical results show that copper recovery in the unit column increased from 12% to 18%, with a slight increase in grade.

Overall grade was virtually unchanged, but overall copper recovery dropped by 1%.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	193.2 kg/h	-1/4 inch	(Wet Sple 1258.2 g) (Dry Sple 1233.4 g)
Feed Rate:	189.4 kg/h	dry ore	(Moisture 1.97 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,352 kg in 7.00 hr	
	Sample	386 kg in 2.00 hr	
Rod Mill Discharge:	1,692 g/L		(64 % Sol at SG 2.74)
	53.7	% plus 48 mesh	
	31.2	% minus 100 mesh	
Input Power:	42.71	for 3 disc revolutions	
	0.91	kW	(95% drive efficiency)
Average Power:	0.86 kW	Gross	
	0.47 kW	No Load	
	0.39 kW	Net	
Net Power Usage:	2.06 kWh/t	of -1/4 inch feed	
K80 Feed:	3,959	microns	
K80 Product:	779	microns	
Work Index (metric):	10.3		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 45 % circ. load)
Feed Rate:	85.7 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,140 g/L		(19 % Sol at SG 2.74)
Ball Mill Discharge:	1,568 g/L		(57 % Sol at SG 2.74)
	22.5	% plus 48 mesh	
	52.1	% minus 100 mesh	
Input Power:	34.20	for 3 disc revolutions	
	1.14	kW	(95% drive efficiency)
Average Power:	1.08 kW	Gross	
	0.52 kW	No Load	
	0.56 kW	Net	
Net Power Usage:	6.50 kWh/t	of screen oversize	
K80 Feed:	1269	microns	
K80 Product:	302	microns	
Work Index (metric):	22.1		

3.1.3. Overall Mill Report:

Net Power Usage:	8.57 kWh/t
K80 Feed:	3,959 microns
K80 Product:	302 microns
Work Index (metric):	20.6
Screen Undersize:	55.6 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	3,959	15.5
Rod Mill Discharge	779	31.2
Column Feed	595	39.3
Column Conc	74	95.2
Column Tail	684	31.9
Ball Mill Feed	762	4.0
Ball Mill Discharge	320	52.1
Screen Undersize	302	55.6
Rougher Feed	266	60.8
Regrind Feed	~37	95.7
Regrind Discharge	~20	99.5
Final Concentrate	129.0	84.9
Final Tail	321	52.7

3.2. Reagent Additions:

Average Feed Rate: 0.189 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	10.0	3.17
	DF-250	0.10%	8.0	2.53
	Pine Oil	100%	5.0 dr	14.26
Rougher Feed	PAX	0.10%	5.0	1.58
Scavenger Feed	PAX	0.10%	12.0	3.80
	DF-250	0.10%	2.0	0.63
	Pine Oil	0.10%	2.0	0.63
Scavenger Cell 4	PAX	0.10%	8.0	2.53
	DF-250	0.10%	4.0	1.27
Total	**PAX**			**11.09**
	DF-250			**4.44**
	Pine Oil			**14.89**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,692			2.74
Ball Mill Discharge	1,568			
Screen Feed	1,240			
Screen Undersize	1,140			
Rougher Feed		8.40	11.2	
Pre-Cleaner Feed		8.30		
Cleaner Feed		8.30		
Scavenger Tail	1,168			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	275.1	1,240	12.1	3.3
Rougher	84	198.6	1,140	15.0	5.6
Scavenger	168	196.9	1,154	13.5	12.4
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results: (45% circulating load)

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

	Direct Assays		Adjusted Assays		Mass Flow
Product	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.43	1.48	0.41	1.49	189.4
Rod Mill Discharge			0.41	1.49	189.4
Ball Mill Discharge	0.23	1.07	0.23	1.00	85.7
Column Feed	0.36	1.32	0.36	1.34	275.1
Column Conc	42.4	18.8	42.7	18.8	0.32
Column Tail (Scr Fd)	0.31	1.34	0.31	1.32	274.7
Screen Oversize	0.23	1.00	0.23	1.00	85.7
Screen Undersize	0.33	1.47	0.34	1.46	189.1
Rougher Feed	0.43	1.66	0.44	1.54	198.6
Rougher Conc	23.9	13.8	22.6	13.2	1.65
Rougher Tail	0.28	1.52	0.26	1.44	196.9
Scav Tail (final)	0.18	1.53	0.15	1.37	188.2
Scavenger Conc	2.50	3.14	2.57	3.14	8.79
Pre-Cleaner Feed	17.5	11.10	22.5	13.2	1.65
Pre-Cleaner Conc	40.2	21.7	40.6	21.6	0.86
Pre-Cleaner Tail	2.86	4.51	3.02	4.18	0.79
Cleaner Feed	2.80	5.13	3.02	4.18	0.79
Cleaner Conc	28.4	17.0	28.2	17.2	0.05
Cleaner Tail	1.22	3.58	1.17	3.23	0.74
Clnr-Scav Conc	19.20	13.30	19.19	13.32	0.00
Clnr-Scav Tail	1.07	3.88	1.13	3.21	0.74
Flotation Conc	41.2	21.4	39.9	21.3	0.22
Combined Conc			41.6	19.8	0.54

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.00	0.41	1.49	100.0	100.0
Combined Conc	0.65	41.6	19.8	65.4	8.7
Final Tail	99.35	0.15	1.37	34.6	91.3
Column Feed	145.24	0.36	1.34	125.2	130.3
Conc	0.17	42.7	18.8	17.5	2.1
Tail	145.07	0.31	1.32	107.7	128.2
Flotation Feed	99.83	0.34	1.46	82.5	97.8
Conc	0.48	39.9	21.3	46.3	6.9
Tail	99.35	0.15	1.37	36.1	90.9
Rougher Feed	104.86	0.44	1.54	112.2	108.4
Conc	0.87	22.6	13.24	47.4	7.7
Tail	103.99	0.26	1.44	64.8	100.7
Scavenger Feed	103.99	0.26	1.44	64.8	100.7
Conc	4.64	2.57	3.14	28.8	9.8
Tail	99.35	0.15	1.37	36.0	90.9
Combined Clnr Feed	0.87	22.6	13.24	47.4	7.7
Flotation Conc	0.48	39.9	21.3	46.3	6.9
Clnr/Scav Tail	0.39	1.13	3.21	1.1	0.8
Pre-Cleaner Feed	0.87	22.5	13.23	47.4	7.7
Conc	0.45	40.6	21.6	44.5	6.6
Tail	0.42	3.02	4.18	3.0	1.2
Cleaner Feed	0.42	3.02	4.18	3.1	1.2
Conc	0.03	28.2	17.2	2.0	0.3
Tail	0.39	1.17	3.23	1.1	0.8
Clnr/Scav Feed	0.39	1.17	3.23	1.1	0.8
Conc	0.00	19.19	13.32	0.0	0.0
Tail	0.39	1.13	3.21	1.1	0.8

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.41	1.49	100.0	100.0
Combined Conc	0.65	41.6	19.8	65.4	8.7
Final Tail	99.3	0.15	1.37	34.6	91.3
Column Feed	100.0	0.36	1.34	100.0	100.0
Conc	0.12	42.7	18.8	14.0	1.6
Tail	99.9	0.31	1.32	86.0	98.4
Flotation Feed	100.0	0.34	1.46	100.0	100.0
Conc	0.48	39.9	21.3	56.2	7.0
Tail	99.5	0.15	1.37	43.8	93.0
Rougher Feed	100.0	0.44	1.54	100.0	100.0
Conc	0.83	22.6	13.2	42.3	7.1
Tail	99.2	0.26	1.44	57.7	92.9
Scavenger Feed	100.0	0.26	1.44	100.0	100.0
Conc	4.5	2.57	3.14	44.4	9.7
Tail	95.5	0.15	1.37	55.6	90.3
Combined Clnr Feed	100.0	22.6	13.2	100.0	100.0
Flotation Conc	55.3	39.9	21.3	97.7	89.1
Clnr/Scav Tail	44.7	1.13	3.21	2.3	10.9
Pre-Cleaner Feed	100.0	22.5	13.23	100.0	100.0
Conc	52.0	40.6	21.6	93.7	84.9
Tail	48.0	3.02	4.18	6.3	15.1
Cleaner Feed	100.0	3.02	4.18	100.0	100.0
Conc	6.92	28.2	17.2	64.8	28.4
Tail	93.1	1.17	3.23	35.2	71.6
Clnr/Scav Feed	100.0	1.17	3.23	100.0	100.0
Conc	0.3	19.19	13.32	4.2	1.1
Tail	99.7	1.13	3.21	95.8	98.9

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	59.1	11.3	11.3	88.7
6	3,327	83.8	16.0	27.3	72.7
8	2,362	62.3	11.9	39.2	60.8
10	1,651	53.8	10.3	49.4	50.6
14	1,168	45.0	8.6	58.0	42.0
20	833	33.7	6.4	64.4	35.6
28	589	28.0	5.3	69.8	30.2
35	417	23.7	4.5	74.3	25.7
48	295	18.3	3.5	77.8	22.2
65	208	18.5	3.5	81.3	18.7
100	147	16.5	3.1	84.5	15.5
150	104	14.4	2.7	87.2	12.8
200	74	13.2	2.5	89.8	10.2
270	53	11.4	2.2	91.9	8.1
400	37	8.4	1.6	93.5	6.5
Pan	-37	33.9	6.5	100.0	-
Total	-	**524.0**	**100.0**	-	-
K80	**3,959**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.9	1.0	1.0	99.0
14	1,168	9.3	5.0	6.0	94.0
20	833	20.0	10.8	16.8	83.2
28	589	27.2	14.6	31.4	68.6
35	417	23.8	12.8	44.3	55.7
48	295	17.5	9.4	53.7	46.3
65	208	14.1	7.6	61.3	38.7
100	147	13.9	7.5	68.8	31.2
150	104	10.8	5.8	74.6	25.4
200	74	9.3	5.0	79.6	20.4
270	53	7.8	4.2	83.8	16.2
400	37	5.2	2.8	86.6	13.4
Pan	-37	24.9	13.4	100.0	-
Total	-	**185.7**	**100.0**	-	-
K80	**779**				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.0	0.5	0.5	99.5
35	417	11.4	6.1	6.6	93.4
48	295	19.7	10.5	17.1	82.9
65	208	18.0	9.6	26.7	73.3
100	147	23.3	12.4	39.2	60.8
150	104	19.6	10.5	49.7	50.3
200	74	17.4	9.3	58.9	41.1
270	53	15.2	8.1	67.1	32.9
400	37	10.8	5.8	72.8	27.2
Pan	-37	50.9	27.2	100.0	-
Total	-	**187.3**	**100.0**	-	-
K80	**266**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	0.4	2.5	2.5	97.5
100	147	0.3	1.9	4.3	95.7
150	104	0.4	2.5	6.8	93.2
200	74	0.6	3.7	10.6	89.4
270	53	0.6	3.7	14.3	85.7
400	37	0.8	5.0	19.3	80.7
Pan	-37	13.0	80.7	100.0	-
Total	-	**16.1**	**100.0**	-	-
K80					

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.0	0.0	0.0	100.0
20	833	0.0	0.0	0.0	100.0
28	589	33.3	21.1	21.1	78.9
35	417	18.2	11.5	32.7	67.3
48	295	17.8	11.3	44.0	56.0
65	208	11.9	7.6	51.5	48.5
100	147	14.5	9.2	60.7	39.3
150	104	11.2	7.1	67.8	32.2
200	74	9.5	6.0	73.9	26.1
270	53	8.1	5.1	79.0	21.0
400	37	6.2	3.9	82.9	17.1
Pan	-37	26.9	17.1	100.0	-
Total	-	157.6	100.0	-	-
K80	595				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	5.2	3.0	3.0	97.0
100	147	3.0	1.7	4.8	95.2
150	104	9.0	5.2	10.0	90.0
200	74	16.8	9.8	19.7	80.3
270	53	26.3	15.3	35.0	65.0
400	37	27.2	15.8	50.8	49.2
Pan	-37	84.8	49.2	100.0	-
Total	-	172.3	100.0	-	-
K80	73.6				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.0	0.0	0.0	100.0
20	833	0.0	0.0	0.0	100.0
28	589	7.0	4.5	4.5	95.5
35	417	12.1	7.7	12.2	87.8
48	295	16.0	10.2	22.5	77.5
65	208	18.5	11.8	34.3	65.7
100	147	21.2	13.6	47.9	52.1
150	104	16.6	10.6	58.5	41.5
200	74	14.0	9.0	67.5	32.5
270	53	12.0	7.7	75.2	24.8
400	37	7.9	5.1	80.2	19.8
Pan	-37	30.9	19.8	100.0	-
Total	-	156.2	100.0	-	-
K80	320				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.9	0.8	0.8	99.2
35	417	22.9	9.4	10.2	89.8
48	295	27.3	11.2	21.3	78.7
65	208	24.7	10.1	31.4	68.6
100	147	31.6	12.9	44.4	55.6
150	104	25.5	10.4	54.8	45.2
200	74	22.0	9.0	63.8	36.2
270	53	18.4	7.5	71.4	28.6
400	37	14.4	5.9	77.3	22.7
Pan	-37	55.5	22.7	100.0	-
Total	-	244.2	100.0	-	-
K80	302				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.0	0.0	0.0	100.0
20	833	0.0	0.0	0.0	100.0
28	589	46.1	28.7	28.7	71.3
35	417	22.0	13.7	42.4	57.6
48	295	18.6	11.6	54.0	46.0
65	208	8.1	5.0	59.0	41.0
100	147	14.6	9.1	68.1	31.9
150	104	11.6	7.2	75.3	24.7
200	74	9.4	5.8	81.1	18.9
270	53	8.2	5.1	86.2	13.8
400	37	4.4	2.7	89.0	11.0
Pan	-37	17.7	11.0	100.0	-
Total	-	160.7	100.0	-	-
K80	684				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	6.8	2.7	2.7	97.3
20	833	27.2	10.9	13.6	86.4
28	589	59.9	24.0	37.6	62.4
35	417	80.0	32.0	69.6	30.4
48	295	43.9	17.6	87.2	12.8
65	208	15.6	6.2	93.5	6.5
100	147	6.4	2.6	96.0	4.0
150	104	2.6	1.0	97.1	2.9
200	74	1.2	0.5	97.6	2.4
270	53	0.9	0.4	97.9	2.1
400	37	0.6	0.2	98.2	1.8
Pan	-37	4.6	1.8	100.0	-
Total	-	249.7	100.0	-	-
K80	762				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.1	0.5	0.5	99.5
150	104	0.1	0.5	1.0	99.0
200	74	0.3	1.4	2.4	97.6
270	53	0.5	2.4	4.8	95.2
400	37	0.7	3.3	8.1	91.9
Pan	-37	19.3	91.9	100.0	-
Total	-	21.0	100.0	-	-
K80					

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	5.2	4.3	4.3	95.7
100	147	13.2	10.8	15.1	84.9
150	104	16.2	13.3	28.3	71.7
200	74	17.3	14.2	42.5	57.5
270	53	15.7	12.9	55.4	44.6
400	37	10.9	8.9	64.3	35.7
Pan	-37	43.6	35.7	100.0	-
Total	-	122.1	100.0	-	-
K80	129				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.6	1.0	1.0	99.0
35	417	15.4	10.0	11.0	89.0
48	295	18.8	12.2	23.2	76.8
65	208	18.0	11.6	34.8	65.2
100	147	19.4	12.5	47.3	52.7
150	104	15.6	10.1	57.4	42.6
200	74	13.1	8.5	65.9	34.1
270	53	10.7	6.9	72.8	27.2
400	37	8.1	5.2	78.1	21.9
Pan	-37	33.9	21.9	100.0	-
Total	-	154.6	100.0	-	-
K80	321				

Test No. PP-13

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 45.4 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	1.0	0.0	0.0	0.0	0.0
14	5.0	0.0	2.7	0.0	0.0
20	10.8	0.0	10.9	0.0	0.0
28	14.6	0.8	24.0	4.5	21.1
35	12.8	9.4	32.0	7.7	11.5
48	9.4	11.2	17.6	10.2	11.3
65	7.6	10.1	6.2	11.8	7.6
100	7.5	12.9	2.6	13.6	9.2
150	5.8	10.4	1.0	10.6	7.1
200	5.0	9.0	0.5	9.0	6.0
270	4.2	7.5	0.4	7.7	5.1
400	2.8	5.9	0.2	5.1	5.1
Pan	13.4	22.7	1.8	19.8	15.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	1.0	0.0
14	184 %	1.8	3.2
20	99 %	5.4	5.4
28	71 %	10.4	7.4
35	14 %	12.2	1.7
48	-24 %	9.2	-2.2
65	45 %	8.9	4.0
100	50 %	9.5	4.7
150	48 %	7.4	3.6
200	47 %	6.3	3.0
270	46 %	5.3	2.4
400	64 %	3.7	2.4
Pan	52 %	19.0	9.9
Total	--	**100.0**	**45.4 %**

Test No. PP-14

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	35.2 % -100 mesh
Rod Mill Feed Grade	0.40 % Cu
Column Conc Grade	51.1 % Cu
Column Copper Rec'y	16.8 %
Flotation Feed Size	57.4 % -100 mesh
Flotation Head Grade	0.33 % Cu
Final Tails Grade	0.15 % Cu
Flotation Copper Grade	23.8 % Cu
Flotation Copper Rec'y	45.2 %
Combined Grade	25.4 % Cu
Combined Recovery	56.6 %

The circuit operated well and the column produced very high grades.
Material handling problems were experienced once again, during the sample period. As a result, the circuit was in a state of imbalance during the sample period, and determination of a self-coherent mass balance around the circuit required significant adjustment of several streams.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	193.1 kg/h	-1/4 inch	(Wet Sple 1042.1 g)
			(Dry Sple 1021.2 g)
Feed Rate:	189.2 kg/h	dry ore	(Moisture 2.01 %)
Mill Speed:	45 RPM	(85% of critical speed)	
Rod Load:	100 kg		
Rod Mill Feed:	Total	772 kg in 4.00 hr	
	Sample	386 kg in 2.00 hr	
Rod Mill Discharge:	1,670 g/L	(63 % Sol at SG 2.74)	
	58.3	% plus 48 mesh	
	27.9	% minus 100 mesh	
Input Power:	47.03	for 3 disc revolutions	
	0.83	kW (95% drive efficiency)	
Average Power:	0.79 kW	Gross	
	0.47 kW	No Load	
	0.31 kW	Net	
Net Power Usage:	1.64 kWh/t	of -1/4 inch feed	
K80 Feed:	3,658	microns	
K80 Product:	975	microns	
Work Index (metric):	10.6		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 57 % circ. load)
Feed Rate:	108.6	kg/h	
Mill Speed:	40 RPM	(77% of critical speed)	
Ball Load:	150 kg		
Screen Undersize:	1,132 g/L	(18 % Sol at SG 2.74)	
Ball Mill Discharge:	1,524 g/L	(54 % Sol at SG 2.74)	
	27.1	% plus 48 mesh	
	48.8	% minus 100 mesh	
Input Power:	34.86	for 3 disc revolutions	
	1.12	kW (95% drive efficiency)	
Average Power:	1.06 kW	Gross	
	0.52 kW	No Load	
	0.54 kW	Net	
Net Power Usage:	4.94 kWh/t	of screen oversize	
K80 Feed:	1,283	microns	
K80 Product:	288	microns	
Work Index (metric):	15.9		

3.1.3. Overall Mill Report:

Net Power Usage:	6.58 kWh/t
K80 Feed:	3,658 microns
K80 Product:	288 microns
Work Index (metric):	15.5
Screen Undersize:	57.4 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	3,658	16.3
Rod Mill Discharge	975	27.9
Column Feed	831	35.2
Column Conc	70	98.3
Column Tail	799	35.0
Ball Mill Feed	1,283	3.7
Ball Mill Discharge	374	48.8
Screen Undersize	288	57.4
Rougher Feed	243	65.2
Regrind Feed	~32	98.1
Regrind Discharge	~9	94.2
Final Concentrate	109	91.1
Final Tail	223	65.4

3.2. Reagent Additions:

Average Feed Rate: 0.189 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	10.0	3.17
	DF-250	0.10%	8.0	2.54
	Pine Oil	100%	5.0 dr	14.27
Rougher Feed	PAX	0.10%	5.0	1.59
Scavenger Feed	PAX	0.10%	12.0	3.80
	DF-250	0.10%	2.0	0.63
	Pine Oil	0.10%	2.0	0.63
Scavenger Cell 4	PAX	0.10%	8.0	2.54
	DF-250	0.10%	4.0	1.27
Total	**PAX**			**11.10**
	DF-250			**4.44**
	Pine Oil			**14.90**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,670			2.74
Ball Mill Discharge	1,524			
Screen Feed	1,160			
Screen Undersize	1,132			
Rougher Feed		8.00	12.0	
Pre-Cleaner Feed		8.00		
Cleaner Feed		8.00		
Scavenger Tail	1,118			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	297.9	1,160	19.7	2.0
Rougher	84	195.9	1,132	15.7	5.3
Scavenger	168	194.3	1,125	16.4	10.2
Pre-Cleaner*	7.7		measured	1.1	7.0
Cleaner*	7.7		measured	1.0	7.7
Clnr/Scav*	7.7		measured	0.9	8.6

4. Metallurgical Results: (57% circulating load)

4.1. Direct Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.44	1.55	0.40	1.54	189.2
Rod Mill Discharge	--	--	0.40	1.54	189.2
Ball Mill Discharge	0.26	1.14	0.24	1.02	108.6
Column Feed	0.35	1.36	0.34	1.35	297.9
Column Conc	50.2	21.1	51.1	21.1	0.25
Column Tail (Scr Fd)	0.31	1.39	0.30	1.33	297.6
Screen Oversize	0.23	1.00	0.24	1.02	108.6
Screen Undersize	0.30	1.47	0.33	1.51	189.0
Rougher Feed	0.33	1.64	0.49	1.64	195.9
Rougher Conc	21.9	12.7	20.8	12.2	1.63
Rougher Tail	0.36	1.56	0.32	1.55	194.3
Scav Tail (final)	0.18	0.14	0.15	1.42	187.6
Scavenger Conc	5.47	5.16	5.20	5.20	6.69
Pre-Cleaner Feed	18.9	11.6	18.5	11.4	1.87
Pre-Cleaner Conc	21.1	10.7	23.8	13.8	1.40
Pre-Cleaner Tail	2.80	4.62	2.95	4.32	0.47
Cleaner Feed	2.48	4.87	2.95	4.32	0.47
Cleaner Conc	27.1	16.8	27.0	6.8	0.02
Cleaner Tail	1.62	4.33	2.03	4.22	0.45
Clnr-Scav Conc	17.3	13.2	2.81	6.10	0.24
Clnr-Scav Tail	1.13	4.08	1.02	2.06	0.21
Flotation Conc	42.5	21.5	23.8	13.8	1.42
Combined Conc			25.4	13.4	1.67

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.00	0.40	1.54	100.0	100.0
Combined Conc	0.88	25.4	13.4	56.6	7.7
Final Tail	99.12	0.15	1.42	43.4	92.3
Column Feed	157.42	0.34	1.35	134.3	138.0
Conc	0.13	51.1	21.1	16.8	1.8
Tail	157.29	0.30	1.33	117.5	136.2
Flotation Feed	99.87	0.33	1.51	83.2	98.2
Conc	0.75	23.8	13.8	45.2	6.7
Tail	99.12	0.15	1.42	38.0	91.5
Rougher Feed	103.52	0.49	1.64	129.5	110.5
Conc	0.86	20.8	12.20	45.4	6.8
Tail	102.66	0.32	1.55	84.0	103.6
Scavenger Feed	102.66	0.32	1.55	84.2	103.6
Conc	3.54	5.20	5.20	46.6	12.0
Tail	99.12	0.15	1.42	37.6	91.6
Combined Clnr Feed	0.86	20.8	12.20	45.4	6.8
Flotation Conc	0.75	23.8	13.8	45.2	6.7
Clnr/Scav Tail	0.11	1.02	2.06	0.3	0.1
Pre-Cleaner Feed	0.99	18.5	11.43	46.4	7.3
Conc	0.74	23.8	13.8	44.6	6.7
Tail	0.25	2.95	4.32	1.8	0.7
Cleaner Feed	0.25	2.95	4.32	1.8	0.7
Conc	0.01	27.0	6.8	0.6	0.0
Tail	0.24	2.03	4.22	1.2	0.7
Clnr/Scav Feed	0.24	2.03	4.22	1.2	0.7
Conc	0.13	2.81	6.10	0.9	0.5
Tail	0.11	1.02	2.06	0.3	0.2

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.40	1.54	100.0	100.0
Combined Conc	0.88	25.4	13.4	56.6	7.7
Final Tail	99.1	0.15	1.42	43.4	92.3
Column Feed	100.0	0.34	1.35	100.0	100.0
Conc	0.08	51.1	21.1	12.5	1.3
Tail	99.9	0.30	1.33	87.5	98.7
Flotation Feed	100.0	0.33	1.51	100.0	100.0
Conc	0.75	23.8	13.8	54.3	6.8
Tail	99.2	0.15	1.42	45.7	93.2
Rougher Feed	100.0	0.49	1.64	100.0	100.0
Conc	0.83	20.8	12.2	35.1	6.2
Tail	99.2	0.32	1.55	64.9	93.8
Scavenger Feed	100.0	0.32	1.55	100.0	100.0
Conc	3.4	5.20	5.20	55.3	11.5
Tail	96.6	0.15	1.42	44.7	88.5
Combined Clnr Feed	100.0	20.8	12.2	100.0	100.0
Flotation Conc	87.0	23.8	13.8	99.4	98.1
Clnr/Scav Tail	13.0	1.02	2.06	0.6	1.9
Pre-Cleaner Feed	100.0	18.5	11.43	100.0	100.0
Conc	75.0	23.8	13.8	96.1	90.6
Tail	25.0	2.95	4.32	3.9	9.4
Cleaner Feed	100.0	2.95	4.32	100.0	100.0
Conc	3.64	27.0	6.8	33.4	5.8
Tail	96.4	2.03	4.22	66.6	94.2
Clnr/Scav Feed	100.0	2.03	4.22	100.0	100.0
Conc	52.9	2.81	6.10	73.2	76.6
Tail	47.1	1.02	2.06	26.8	23.4

5. Screen Analyses: Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	44.6	10.0	10.0	90.0
6	3,327	57.0	12.8	22.9	77.1
8	2,362	61.2	13.8	36.6	63.4
10	1,651	46.9	10.6	47.2	52.8
14	1,168	40.0	9.0	56.2	43.8
20	833	29.4	6.6	62.8	37.2
28	589	25.6	5.8	68.6	31.4
35	417	21.3	4.8	73.4	26.6
48	295	16.6	3.7	77.1	22.9
65	208	15.7	3.5	80.6	19.4
100	147	13.8	3.1	83.7	16.3
150	104	11.5	2.6	86.3	13.7
200	74	10.8	2.4	88.7	11.3
270	53	9.6	2.2	90.9	9.1
400	37	6.8	1.5	92.4	7.6
Pan	-37	33.6	7.6	100.0	-
Total	-	444.4	100.0	-	-
K80	3,658				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	5.5	2.4	2.4	97.6
14	1,168	21.5	9.4	11.7	88.3
20	833	33.4	14.5	26.3	73.7
28	589	31.1	13.5	39.8	60.2
35	417	24.9	10.8	50.6	49.4
48	295	17.7	7.7	58.3	41.7
65	208	17.5	7.6	65.9	34.1
100	147	14.2	6.2	72.1	27.9
150	104	11.0	4.8	76.9	23.1
200	74	9.4	4.1	81.0	19.0
270	53	8.2	3.6	84.6	15.4
400	37	5.5	2.4	87.0	13.0
Pan	-37	30.0	13.0	100.0	-
Total	-	229.9	100.0	-	-
K80	975				

Test No. PP-14

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.8	2.2	2.2	97.8
14	1,168	12.6	7.2	9.3	90.7
20	833	17.4	9.9	19.2	80.8
28	589	17.5	10.0	29.2	70.8
35	417	16.8	9.6	38.8	61.2
48	295	14.8	8.4	47.2	52.8
65	208	16.4	9.3	56.5	43.5
100	147	14.6	8.3	64.8	35.2
150	104	11.4	6.5	71.3	28.7
200	74	9.7	5.5	76.8	23.2
270	53	8.0	4.6	81.4	18.6
400	37	5.6	3.2	84.6	15.4
Pan	-37	27.1	15.4	100.0	-
Total	-	**175.7**	**100.0**	-	-
K80	**811**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.6	0.5	0.5	99.5
100	147	1.4	1.2	1.7	98.3
150	104	5.2	4.4	6.0	94.0
200	74	13.2	11.1	17.1	82.9
270	53	21.8	18.3	35.4	64.6
400	37	21.4	18.0	53.4	46.6
Pan	-37	55.6	46.6	100.0	-
Total	-	**119.2**	**100.0**	-	-
K80	**70.4**				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.1	1.8	1.8	98.2
14	1,168	15.5	6.7	8.5	91.5
20	833	23.6	10.2	18.7	81.3
28	589	25.3	10.9	29.6	70.4
35	417	23.5	10.1	39.7	60.3
48	295	20.6	8.9	48.6	51.4
65	208	19.0	8.2	56.8	43.2
100	147	18.9	8.2	65.0	35.0
150	104	15.1	6.5	71.5	28.5
200	74	12.4	5.4	76.9	23.1
270	53	10.9	4.7	81.6	18.4
400	37	6.9	3.0	84.5	15.5
Pan	-37	35.8	15.5	100.0	-
Total	-	**231.6**	**100.0**	-	-
K80	**799**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	15.4	5.6	5.6	94.4
14	1,168	51.6	18.8	24.4	75.6
20	833	69.3	25.3	49.7	50.3
28	589	66.6	24.3	74.0	26.0
35	417	36.3	13.2	87.2	12.8
48	295	14.5	5.3	92.5	7.5
65	208	7.4	2.7	95.2	4.8
100	147	2.9	1.1	96.3	3.7
150	104	1.5	0.5	96.8	3.2
200	74	0.9	0.3	97.2	2.8
270	53	0.7	0.3	97.4	2.6
400	37	0.5	0.2	97.6	2.4
Pan	-37	6.6	2.4	100.0	-
Total	-	**274.2**	**100.0**	-	-
K80	**1,283**				

Test No. PP-14

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.5	0.3	0.3	99.7
14	1,168	1.4	0.9	1.3	98.7
20	833	3.2	2.1	3.4	96.6
28	589	7.2	4.7	8.1	91.9
35	417	13.3	8.8	16.9	83.1
48	295	15.5	10.2	27.1	72.9
65	208	18.9	12.5	39.5	60.5
100	147	17.7	11.7	51.2	48.8
150	104	14.5	9.6	60.7	39.3
200	74	12.5	8.2	69.0	31.0
270	53	10.0	6.6	75.6	24.4
400	37	7.9	5.2	80.8	19.2
Pan	-37	29.2	19.2	100.0	-
Total	-	**151.8**	**100.0**	-	-
K80	374				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.8	0.8	0.8	99.2
35	417	8.3	8.1	8.9	91.1
48	295	10.8	10.6	19.5	80.5
65	208	10.5	10.3	29.8	70.2
100	147	13.1	12.8	42.6	57.4
150	104	10.3	10.1	52.7	47.3
200	74	9.0	8.8	61.5	38.5
270	53	7.9	7.7	69.2	30.8
400	37	5.5	5.4	74.6	25.4
Pan	-37	25.9	25.4	100.0	-
Total	-	**102.1**	**100.0**	-	-
K80	288				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.2	0.7	0.7	99.3
35	417	8.9	5.3	6.0	94.0
48	295	15.5	9.2	15.2	84.8
65	208	14.2	8.4	23.6	76.4
100	147	18.9	11.2	34.8	65.2
150	104	17.6	10.4	45.2	54.8
200	74	16.4	9.7	54.9	45.1
270	53	14.6	8.6	63.6	36.4
400	37	11.5	6.8	70.4	29.6
Pan	-37	50.0	29.6	100.0	-
Total	-	**168.8**	**100.0**	-	-
K80	**243**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	0.5	2.2	2.2	97.8
100	147	0.8	3.6	5.8	94.2
150	104	0.9	4.0	9.8	90.2
200	74	0.7	3.1	12.9	87.1
270	53	0.6	2.7	15.6	84.4
400	37	0.7	3.1	18.7	81.3
Pan	-37	18.3	81.3	100.0	-
Total	-	**22.5**	**100.0**	-	-
K80	**~32**				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.3	1.9	1.9	98.1
100	147	0.3	1.9	3.7	96.3
150	104	0.3	1.9	5.6	94.4
200	74	0.4	2.5	8.0	92.0
270	53	0.3	1.9	9.9	90.1
400	37	0.7	4.3	14.2	85.8
Pan	-37	13.9	85.8	100.0	-
Total	-	**16.2**	**100.0**	-	-
K80	~9				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.4	2.3	2.3	97.7
100	147	7.1	6.7	8.9	91.1
150	104	12.9	12.1	21.1	78.9
200	74	17.0	16.0	37.0	63.0
270	53	15.2	14.3	51.3	48.7
400	37	10.7	10.1	61.4	38.6
Pan	-37	41.1	38.6	100.0	-
Total	-	**106.4**	**100.0**	-	-
K80	109				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.3	0.1	0.1	99.9
35	417	8.4	3.9	4.1	95.9
48	295	18.2	8.5	12.6	87.4
65	208	18.0	8.4	21.0	79.0
100	147	29.3	13.7	34.6	65.4
150	104	24.6	11.5	46.1	53.9
200	74	21.1	9.8	55.9	44.1
270	53	18.8	8.8	64.7	35.3
400	37	12.2	5.7	70.4	29.6
Pan	-37	63.4	29.6	100.0	-
Total	-	**214.3**	**100.0**	-	-
K80	223				

Test No. PP-14

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 58.4 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	2.4	0.0	5.6	0.3	2.2
14	9.4	0.0	18.8	0.9	7.2
20	14.5	0.0	25.3	2.1	9.9
28	13.5	0.8	24.3	4.7	10.0
35	10.8	8.1	13.2	8.8	9.6
48	7.7	10.6	5.3	10.2	8.4
65	7.6	10.3	2.7	12.5	9.3
100	6.2	12.8	1.1	11.7	8.3
150	4.8	10.1	0.5	9.6	6.5
200	4.1	8.8	0.3	8.2	5.5
270	3.6	7.7	0.3	6.6	4.6
400	2.4	5.4	0.2	5.2	4.6
Pan	13.0	25.4	2.4	19.2	14.1
Total	100.0	100.0	100.0	100.0	100.0

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	2.4	0.0
14	52 %	6.5	3.4
20	63 %	9.7	6.1
28	65 %	10.1	6.6
35	60 %	10.1	6.1
48	58 %	8.6	5.0
65	27 %	8.7	2.4
100	63 %	8.3	5.2
150	59 %	6.6	3.9
200	60 %	5.6	3.4
270	66 %	4.8	3.1
400	60 %	3.4	2.1
Pan	73 %	15.3	11.2
Total	--	100.0	58.4 %

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	31.4 %	-100 mesh
Rod Mill Feed Grade	0.44 %	Cu
Column Conc Grade	43.9 %	Cu
Column Copper Rec'y	56.4 %	
Flotation Feed Size	55.4 %	-100 mesh
Flotation Head Grade	0.19 %	Cu
Final Tails Grade	0.05 %	Cu
Flotation Copper Grade	11.1 %	Cu
Flotation Copper Rec'y	32.3 %	
Combined Grade	21.2 %	Cu
Combined Recovery	88.7 %	

The dosages of PAX and DF-250 in the unit column circuit were increased, as was the PAX dosage in the rougher.

Recovery of copper in the unit column increased dramatically to about 56%. Recovery in the conventional circuit was accordingly reduced to about 32%, but the grade dropped to only 11% Cu. It appeared that far too much copper was removed from the circuit in the unit column, leaving the conventional circuit with a feed grade of only 0.19 %Cu, from which an acceptable grade concentrate could not be made.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	197.8 kg/h	-1/4 inch	(Wet Sple 1528.1 g) (Dry Sple 1496.7 g)
Feed Rate:	193.7 kg/h	dry ore	(Moisture 2.05 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,335 kg in 6.75 hr	
	Sample	593 kg in 3.00 hr	
Rod Mill Discharge:	1,603 g/L		(59 % Sol at SG 2.75)
	57.4	% plus 48 mesh	
	28.7	% minus 100 mesh	
Input Power:	46.62	for 3 disc revolutions	
	0.83	kW (95% drive efficiency)	
Average Power:	0.79 kW	Gross	
	0.47 kW	No Load	
	0.32 kW	Net	
Net Power Usage:	1.64 kWh/t	of -1/4 inch feed	
K80 Feed:	4,048	microns	
K80 Product:	951	microns	
Work Index (metric):	9.8		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 73 % circ. load)
Feed Rate:	140.9 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,192 g/L		(25 % Sol at SG 2.75)
Ball Mill Discharge:	1,642 g/L		(61 % Sol at SG 2.75)
	38.6	% plus 48 mesh	
	39.2	% minus 100 mesh	
Input Power:	34.44	for 3 disc revolutions	
	1.13	kW (95% drive efficiency)	
Average Power:	1.07 kW	Gross	
	0.52 kW	No Load	
	0.55 kW	Net	
Net Power Usage:	3.90 kWh/t	of screen oversize	
K80 Feed:	1,245	microns	
K80 Product:	288	microns	
Work Index (metric):	12.8		

3.1.3. Overall Mill Report:

Net Power Usage:	5.54 kWh/t
K80 Feed:	4,048 microns
K80 Product:	288 microns
Work Index (metric):	12.8
Screen Undersize:	55.4 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,048	15.2
Rod Mill Discharge	951	28.7
Column Feed	851	31.4
Column Conc	97	92.6
Column Tail	800	33.1
Ball Mill Feed	1,245	3.9
Ball Mill Discharge	504	31.4
Screen Undersize	288	55.4
Rougher Feed	243	63.1
Regrind Feed	~74	84.4
Regrind Discharge	~35	99.4
Final Concentrate	79	91.6
Final Tail	307	53.7

3.2. Reagent Additions:

Average Feed Rate: 0.194 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	12.0	3.72
	DF-250	0.10%	10.0	3.10
	Pine Oil	100%	5.0 dr	13.94
Rougher Feed	PAX	0.10%	7.0	2.17
Scavenger Feed	PAX	0.10%	12.0	3.72
	DF-250	0.10%	2.0	0.62
	Pine Oil	0.10%	2.0	0.62
Scavenger Cell 4	PAX	0.10%	8.0	2.48
	DF-250	0.10%	4.0	1.24
Total	**PAX**			**12.08**
	DF-250			**4.96**
	Pine Oil			**14.56**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,603			2.75
Ball Mill Discharge	1,642			
Screen Feed	1,308			
Screen Undersize	1,192			
Rougher Feed		8.00	1,250	
Pre-Cleaner Feed		8.00		
Cleaner Feed		8.00		
Scavenger Tail	1,250			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	334.7	1,308	11.5	3.5
Rougher	84	199.8	1,192	11.0	7.6
Scavenger	168	194.4	1,221	9.3	18.0
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results: (73% circulating load)

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow kg/h
	% Cu	% Fe	% Cu	% Fe	
Rod Mill Feed	0.44	1.45	0.44	1.41	193.7
Rod Mill Discharge			0.44	1.41	193.7
Ball Mill Discharge	0.19	0.89	0.21	0.88	140.9
Column Feed	0.34	1.24	0.34	1.19	334.7
Column Conc	43.7	19.5	43.9	19.6	1.08
Column Tail (Scr Fd)	0.20	1.11	0.20	1.13	333.6
Screen Oversize	0.21	0.87	0.21	0.88	140.9
Screen Undersize	0.19	1.26	0.19	1.31	192.7
Rougher Feed	0.18	1.33	0.27	1.38	199.8
Rougher Conc	21.9	12.7	5.11	5.35	5.41
Rougher Tail	0.21	1.33	0.13	1.27	194.4
Scav Tail (final)	0.11	1.28	0.05	1.21	190.2
Scavenger Conc	3.16	3.71	3.55	3.87	4.21
Pre-Cleaner Feed	6.56	6.05	5.32	5.51	5.48
Pre-Cleaner Conc	12.1	8.95	11.1	8.50	2.45
Pre-Cleaner Tail	0.69	2.91	0.59	3.35	3.03
Cleaner Feed	0.87	4.28	0.59	3.35	3.03
Cleaner Conc	12.2	10.5	12.1	10.5	0.00
Cleaner Tail	0.69	3.68	0.67	3.05	3.03
Clnr-Scav Conc	8.07	9.38	3.23	7.40	0.08
Clnr-Scav Tail	0.53	2.89	0.54	2.93	2.95
Flotation Conc	12.2	9.02	11.1	8.50	2.45
Combined Conc			21.2	11.9	3.54

4.2. Overall Metallurgical Balance:

	Overall	Assays		Distributions (%)	
Product	Wt %	Cu	Fe	Cu	Fe
Rod Mill Feed	100.00	0.44	1.41	100.0	100.0
Combined Conc	1.83	21.2	11.9	88.7	15.4
Final Tail	98.17	0.05	1.21	11.3	84.6
Column Feed	172.75	0.34	1.19	135.1	145.4
Conc	0.56	43.9	19.6	56.4	7.8
Tail	172.19	0.20	1.13	78.7	137.6
Flotation Feed	99.44	0.19	1.31	43.6	92.2
Conc	1.27	11.1	8.5	32.3	7.7
Tail	98.17	0.05	1.21	11.2	84.5
Rougher Feed	103.14	0.27	1.38	63.2	101.3
Conc	2.79	5.1	5.35	32.7	10.6
Tail	100.35	0.13	1.27	30.5	90.7
Scavenger Feed	100.35	0.13	1.27	29.0	90.5
Conc	2.17	3.55	3.87	17.7	6.0
Tail	98.17	0.05	1.21	11.3	84.5
Combined Clnr Feed	2.79	5.1	5.35	32.7	10.6
Flotation Conc	1.27	11.1	8.5	32.3	7.7
Clnr/Scav Tail	1.52	0.54	2.93	0.4	2.9
Pre-Cleaner Feed	2.83	5.3	5.51	34.5	11.1
Conc	1.27	11.1	8.5	32.3	7.6
Tail	1.57	0.59	3.35	2.2	3.4
Cleaner Feed	1.57	0.59	3.35	2.1	3.7
Conc	0.00	12.1	10.5	0.0	0.0
Tail	1.56	0.67	3.05	2.1	3.7
Clnr/Scav Feed	1.56	0.67	3.05	2.4	3.4
Conc	0.04	3.23	7.40	0.3	0.2
Tail	1.53	0.54	2.93	2.1	3.2

4.3. Individual Unit Performance:

	Overall	Assays		Distributions (%)	
Product	Wt %	Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.44	1.41	100.0	100.0
Combined Conc	1.83	21.2	11.9	88.7	15.4
Final Tail	98.2	0.05	1.21	11.3	84.6
Column Feed	100.0	0.34	1.19	100.0	100.0
Conc	0.32	43.9	19.6	41.7	5.4
Tail	99.7	0.20	1.13	58.3	94.6
Flotation Feed	100.0	0.19	1.31	100.0	100.0
Conc	1.27	11.1	8.5	74.2	8.3
Tail	98.7	0.05	1.21	25.8	91.7
Rougher Feed	100.0	0.27	1.38	100.0	100.0
Conc	2.71	5.1	5.3	51.8	10.5
Tail	97.3	0.13	1.27	48.2	89.5
Scavenger Feed	100.0	0.13	1.27	100.0	100.0
Conc	2.2	3.55	3.87	60.9	6.6
Tail	97.8	0.05	1.21	39.1	93.4
Combined Clnr Feed	100.0	5.1	5.3	100.0	100.0
Flotation Conc	45.4	11.1	8.5	98.9	72.2
Clnr/Scav Tail	54.6	0.54	2.93	1.1	27.8
Pre-Cleaner Feed	100.0	5.3	5.51	100.0	100.0
Conc	44.7	11.1	8.5	93.5	69.0
Tail	55.3	0.59	3.35	6.5	31.0
Cleaner Feed	100.0	0.59	3.35	100.0	100.0
Conc	0.06	12.1	10.5	1.3	0.2
Tail	99.9	0.67	3.05	98.7	99.8
Clnr/Scav Feed	100.0	0.67	3.05	100.0	100.0
Conc	2.56	3.2	7.4	12.3	6.2
Tail	97.4	0.54	2.93	87.7	93.8

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	40.1	12.1	12.1	87.9
6	3,327	51.8	15.6	27.7	72.3
8	2,362	44.0	13.3	41.0	59.0
10	1,651	29.8	9.0	50.0	50.0
14	1,168	26.8	8.1	58.1	41.9
20	833	20.6	6.2	64.3	35.7
28	589	18.2	5.5	69.8	30.2
35	417	15.5	4.7	74.5	25.5
48	295	12.2	3.7	78.2	21.8
65	208	12.2	3.7	81.9	18.1
100	147	9.7	2.9	84.8	15.2
150	104	8.7	2.6	87.4	12.6
200	74	8.1	2.4	89.9	10.1
270	53	7.0	2.1	92.0	8.0
400	37	5.4	1.6	93.6	6.4
Pan	-37	21.2	6.4	100.0	-
Total	-	331.3	100.0	-	-
K80	4,048				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.5	1.9	1.9	98.1
14	1,168	20.9	9.0	11.0	89.0
20	833	32.7	14.1	25.1	74.9
28	589	31.1	13.4	38.5	61.5
35	417	25.2	10.9	49.4	50.6
48	295	18.4	8.0	57.4	42.6
65	208	16.8	7.3	64.6	35.4
100	147	15.4	6.7	71.3	28.7
150	104	12.3	5.3	76.6	23.4
200	74	10.3	4.5	81.1	18.9
270	53	9.2	4.0	85.0	15.0
400	37	5.5	2.4	87.4	12.6
Pan	-37	29.1	12.6	100.0	-
Total	-	231.4	100.0	-	-
K80	951				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.9	2.2	2.2	97.8
14	1,168	16.7	7.5	9.7	90.3
20	833	24.2	10.9	20.6	79.4
28	589	25.4	11.4	32.0	68.0
35	417	24.5	11.0	43.0	57.0
48	295	20.4	9.2	52.2	47.8
65	208	19.7	8.9	61.1	38.9
100	147	16.8	7.6	68.6	31.4
150	104	13.4	6.0	74.6	25.4
200	74	11.4	5.1	79.8	20.2
270	53	9.6	4.3	84.1	15.9
400	37	7.2	3.2	87.3	12.7
Pan	-37	28.2	12.7	100.0	-
Total	-	**222.4**	**100.0**	-	-
K80	**851**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	6.7	2.5	2.5	97.5
100	147	12.9	4.9	7.4	92.6
150	104	25.2	9.5	16.9	83.1
200	74	40.8	15.4	32.3	67.7
270	53	48.3	18.2	50.6	49.4
400	37	36.1	13.6	64.2	35.8
Pan	-37	94.8	35.8	100.0	-
Total	-	**264.8**	**100.0**	-	-
K80	**97.1**				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.8	2.1	2.1	97.9
14	1,168	12.7	6.9	9.0	91.0
20	833	17.8	9.7	18.7	81.3
28	589	20.0	10.9	29.6	70.4
35	417	20.2	11.0	40.7	59.3
48	295	17.4	9.5	50.2	49.8
65	208	16.4	9.0	59.1	40.9
100	147	14.2	7.8	66.9	33.1
150	104	11.1	6.1	72.9	27.1
200	74	9.6	5.2	78.2	21.8
270	53	8.3	4.5	82.7	17.3
400	37	5.6	3.1	85.8	14.2
Pan	-37	26.1	14.2	100.0	-
Total	-	**183.2**	**100.0**	-	-
K80	**800**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	17.4	5.8	5.8	94.2
14	1,168	48.4	16.2	22.1	77.9
20	833	71.1	23.9	45.9	54.1
28	589	74.9	25.1	71.0	29.0
35	417	44.8	15.0	86.1	13.9
48	295	17.6	5.9	92.0	8.0
65	208	8.8	3.0	94.9	5.1
100	147	3.5	1.2	96.1	3.9
150	104	1.9	0.6	96.7	3.3
200	74	1.4	0.5	97.2	2.8
270	53	1.2	0.4	97.6	2.4
400	37	1.0	0.3	98.0	2.0
Pan	-37	6.1	2.0	100.0	-
Total	-	**298.1**	**100.0**	-	-
K80	**1,245**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.7	1.0	1.0	99.0
14	1,168	3.6	2.2	3.3	96.7
20	833	6.1	3.8	7.0	93.0
28	589	12.4	7.6	14.7	85.3
35	417	19.2	11.8	26.5	73.5
48	295	19.6	12.1	38.6	61.4
65	208	20.3	12.5	51.1	48.9
100	147	15.7	9.7	60.8	39.2
150	104	12.7	7.8	68.6	31.4
200	74	10.5	6.5	75.1	24.9
270	53	8.7	5.4	80.5	19.5
400	37	6.9	4.3	84.7	15.3
Pan	-37	24.8	15.3	100.0	-
Total	-	**162.2**	**100.0**	-	-
K80	**504**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.0	0.7	0.7	99.3
35	417	10.8	7.3	8.0	92.0
48	295	16.7	11.3	19.3	80.7
65	208	18.3	12.4	31.6	68.4
100	147	19.2	13.0	44.6	55.4
150	104	14.8	10.0	54.6	45.4
200	74	12.8	8.7	63.3	36.7
270	53	11.1	7.5	70.8	29.2
400	37	7.9	5.3	76.1	23.9
Pan	-37	35.3	23.9	100.0	-
Total	-	**147.9**	**100.0**	-	-
K80	**288**				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.8	0.5	0.5	99.5
35	417	8.3	4.7	5.2	94.8
48	295	15.6	8.8	14.0	86.0
65	208	18.5	10.5	24.5	75.5
100	147	21.9	12.4	36.9	63.1
150	104	18.9	10.7	47.6	52.4
200	74	17.0	9.6	57.2	42.8
270	53	15.0	8.5	65.7	34.3
400	37	10.6	6.0	71.7	28.3
Pan	-37	50.0	28.3	100.0	-
Total	-	**176.6**	**100.0**	-	-
K80	**243**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	5.4	12.4	12.4	87.6
100	147	1.4	3.2	15.6	84.4
150	104	0.8	1.8	17.4	82.6
200	74	1.0	2.3	19.7	80.3
270	53	1.4	3.2	22.9	77.1
400	37	1.2	2.7	25.6	74.4
Pan	-37	32.5	74.4	100.0	-
Total	-	**43.7**	**100.0**	-	-
K80					

Test No. PP-15

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.2	0.6	0.6	99.4
150	104	0.2	0.6	1.1	98.9
200	74	0.6	1.7	2.9	97.1
270	53	1.0	2.9	5.7	94.3
400	37	1.4	4.0	9.7	90.3
Pan	-37	31.6	90.3	100.0	-
Total	-	35.0	100.0	-	-
K80					

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.9	2.9	2.9	97.1
100	147	1.7	5.5	8.4	91.6
150	104	2.0	6.5	14.8	85.2
200	74	1.7	5.5	20.3	79.7
270	53	1.7	5.5	25.8	74.2
400	37	0.3	1.0	26.8	73.2
Pan	-37	22.7	73.2	100.0	-
Total	-	31.0	100.0	-	-
K80	79				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.0	0.6	0.6	99.4
35	417	16.5	9.5	10.1	89.9
48	295	19.7	11.3	21.4	78.6
65	208	20.7	11.9	33.4	66.6
100	147	22.4	12.9	46.3	53.7
150	104	17.1	9.9	56.1	43.9
200	74	14.3	8.2	64.3	35.7
270	53	12.7	7.3	71.7	28.3
400	37	8.6	5.0	76.6	23.4
Pan	-37	40.6	23.4	100.0	-
Total	-	173.6	100.0	-	-
K80	307				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 72.8 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	1.9	0.0	5.8	1.0	2.2
14	9.0	0.0	16.2	2.2	7.5
20	14.1	0.0	23.9	3.8	10.9
28	13.4	0.7	25.1	7.6	11.4
35	10.9	7.3	15.0	11.8	11.0
48	8.0	11.3	5.9	12.1	9.2
65	7.3	12.4	3.0	12.5	8.9
100	6.7	13.0	1.2	9.7	7.6
150	5.3	10.0	0.6	7.8	6.0
200	4.5	8.7	0.5	6.5	5.1
270	4.0	7.5	0.4	5.4	4.3
400	2.4	5.3	0.3	4.3	4.3
Pan	12.6	23.9	2.0	15.3	11.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	1.9	0.0
14	64 %	6.4	4.1
20	70 %	9.8	6.9
28	73 %	11.0	8.0
35	112 %	11.4	12.8
48	54 %	9.4	5.1
65	53 %	9.1	4.9
100	74 %	7.9	5.9
150	65 %	6.3	4.1
200	70 %	5.3	3.7
270	71 %	4.6	3.2
400	76 %	3.2	2.4
Pan	85 %	13.7	11.7
Total	**--**	**100.0**	**72.8 %**

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	29.7 %	-100 mesh
Rod Mill Feed Grade	0.33 %	Cu
Column Conc Grade	47.2 %	Cu
Column Copper Rec'y	23.0 %	
Flotation Feed Size	54.5 %	-100 mesh
Flotation Head Grade	0.25 %	Cu
Final Tails Grade	0.14 %	Cu
Flotation Copper Grade	32.9 %	Cu
Flotation Copper Rec'y	39.7 %	
Combined Grade	37.0 %	Cu
Combined Recovery	62.7 %	

The circuit head grade dropped to about 0.33 %Cu, and metallurgical results were accordingly poorer. In spite of the lower head grade, however, the unit column was still able to produce a high grade product.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	192.3 kg/h	-1/4 inch	(Wet Sple 1528.1 g)
			(Dry Sple 1496.7 g)
Feed Rate:	188.3 kg/h	dry ore	(Moisture 2.05 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,298 kg in 6.75 hr	
	Sample	577 kg in 3.00 hr	
Rod Mill Discharge:	1,626 g/L		(60 % Sol at SG 2.75)
	57.8	% plus 48 mesh	
	28.8	% minus 100 mesh	
Input Power:	46.44	for 3 disc revolutions	
	0.84	kW	(95% drive efficiency)
Average Power:	0.80 kW	Gross	
	0.47 kW	No Load	
	0.32 kW	Net	
Net Power Usage:	1.71 kWh/t	of -1/4 inch feed	
K80 Feed:	4,237	microns	
K80 Product:	992	microns	
Work Index (metric):	10.4		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 75 % circ. load)
Feed Rate:	141.0 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,196 g/L		(26 % Sol at SG 2.75)
Ball Mill Discharge:	1,704 g/L		(65 % Sol at SG 2.75)
	51.6	% plus 48 mesh	
	32.4	% minus 100 mesh	
Input Power:	35.13	for 3 disc revolutions	
	1.11	kW	(95% drive efficiency)
Average Power:	1.05 kW	Gross	
	0.52 kW	No Load	
	0.53 kW	Net	
Net Power Usage:	3.75 kWh/t	of screen oversize	
K80 Feed:	992	microns	
K80 Product:	322	microns	
Work Index (metric):	15.6		

3.1.3. Overall Mill Report:

Net Power Usage:	5.45 kWh/t
K80 Feed:	4,237 microns
K80 Product:	322 microns
Work Index (metric):	13.5
Screen Undersize:	54.5 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	4,327	15.3
Rod Mill Discharge	992	28.8
Column Feed	~~831~~ 849	29.7
Column Conc	78	96.8
Column Tail	892	33.0
Ball Mill Feed	1,244	4.1
Ball Mill Discharge	763	32.4
Screen Undersize	322	54.5
Rougher Feed	290	59.0
Regrind Feed	~35	94.3
Regrind Discharge	~16	100.0
Final Concentrate	145	80.6
Final Tail	332	54.3

3.2. Reagent Additions:

Average Feed Rate: 0.188 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	12.0	3.82
	DF-250	0.10%	8.0	2.55
	Pine Oil	100%	5.0 dr	14.34
Rougher Feed	PAX	0.10%	7.0	2.23
Scavenger Feed	PAX	0.10%	12.0	3.82
	DF-250	0.10%	2.0	0.64
	Pine Oil	0.10%	2.0	0.64
Scavenger Cell 4	PAX	0.10%	8.0	2.55
	DF-250	0.10%	4.0	1.27
Total	**PAX**			**12.42**
	DF-250			**4.46**
	Pine Oil			**14.97**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,626			2.75
Ball Mill Discharge	1,704			
Screen Feed	1,356			
Screen Undersize	1,196			
Rougher Feed		8.10	14.2	
Pre-Cleaner Feed		8.00		
Cleaner Feed		8.10		
Scavenger Tail	1,210			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	329.4	1,356	9.8	4.1
Rougher	84	192.8	1,196	10.4	8.1
Scavenger	168	191.8	1,203	10.0	16.8
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results: (75% circulating load)

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.40	1.27	0.33	1.22	188.3
Rod Mill Discharge			0.33	1.22	188.3
Ball Mill Discharge	0.21	0.89	0.21	1.34	141.0
Column Feed	0.31	1.08	0.28	1.27	329.4
Column Conc	45.4	20.0	47.2	20.0	0.30
Column Tail (Scr Fd)	0.27	1.07	0.24	1.26	329.1
Screen Oversize	0.20	0.76	47.21	20.0	141.0
Screen Undersize	0.22	1.34	0.25	1.19	188.0
Rougher Feed	0.25	1.40	0.36	1.29	192.8
Rougher Conc	10.2	7.32	25.9	13.0	0.95
Rougher Tail	0.28	1.36	0.23	1.23	191.8
Scav Tail (final)	0.12	1.33	0.12	1.13	187.3
Scavenger Conc	5.92	4.88	4.67	5.25	4.54
Pre-Cleaner Feed	11.5	8.54	25.9	13.0	0.95
Pre-Cleaner Conc	35.8	20.1	32.9	16.1	0.74
Pre-Cleaner Tail	2.09	4.20	2.03	2.49	0.22
Cleaner Feed	2.13	4.88	2.03	2.49	0.22
Cleaner Conc	20.0	14.1	30.6	13.8	0.01
Cleaner Tail	1.10	3.86	0.92	2.07	0.21
Clnr-Scav Conc	11.2	10.9	11.3	10.9	0.00
Clnr-Scav Tail	0.99	4.42	0.83	1.99	0.21
Flotation Conc	35.5	19.7	32.8	16.1	0.75
Combined Conc			37.0	17.2	1.05

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.00	0.33	1.22	100.0	100.0
Combined Conc	0.56	37.0	17.2	62.5	7.8
Final Tail	99.44	0.124	1.13	37.5	92.2
Column Feed	174.88	0.28	1.27	148.8	182.3
Conc	0.16	47.2	20.0	23.0	2.6
Tail	174.72	0.24	1.26	125.9	179.7
Flotation Feed	99.84	0.25	1.19	77.1	97.4
Conc	0.40	32.8	16.1	39.5	5.2
Tail	99.44	0.12	1.13	37.5	92.2
Rougher Feed	102.36	0.36	1.29	111.7	107.9
Conc	0.51	25.9	13.01	39.7	5.4
Tail	101.85	0.23	1.23	71.9	102.5
Scavenger Feed	101.85	0.23	1.23	71.8	102.5
Conc	2.41	4.67	5.25	34.2	10.4
Tail	99.44	0.124	1.13	37.6	92.2
Combined Clnr Feed	0.51	25.9	13.01	39.7	5.4
Flotation Conc	0.40	32.8	16.1	39.5	5.2
Clnr/Scav Tail	0.11	0.83	1.99	0.2	0.2
Pre-Cleaner Feed	0.51	25.9	13.00	39.8	5.4
Conc	0.39	32.9	16.1	39.1	5.2
Tail	0.12	2.03	2.49	0.7	0.2
Cleaner Feed	0.12	2.03	2.49	0.7	0.2
Conc	0.00	30.6	13.8	0.4	0.0
Tail	0.11	0.92	2.07	0.3	0.2
Clnr/Scav Feed	0.11	0.92	2.07	0.3	0.2
Conc	0.00	11.30	10.94	0.0	0.0
Tail	0.11	0.83	1.99	0.3	0.2

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.33	1.22	100.0	100.0
Combined Conc	0.56	37.0	17.2	62.5	7.8
Final Tail	99.4	0.124	1.13	37.5	92.2
Column Feed	100.0	0.28	1.27	100.0	100.0
Conc	0.09	47.2	20.0	15.4	1.4
Tail	99.9	0.24	1.26	84.6	98.6
Flotation Feed	100.0	0.25	1.19	100.0	100.0
Conc	0.40	32.8	16.1	51.3	5.4
Tail	99.6	0.12	1.13	48.7	94.6
Rougher Feed	100.0	0.36	1.29	100.0	100.0
Conc	0.49	25.9	13.0	35.6	5.0
Tail	99.5	0.23	1.23	64.4	95.0
Scavenger Feed	100.0	0.23	1.23	100.0	100.0
Conc	2.4	4.67	5.25	47.6	10.1
Tail	97.6	0.124	1.13	52.4	89.9
Combined Clnr Feed	100.0	25.9	13.0	100.0	100.0
Flotation Conc	78.4	32.8	16.1	99.5	96.8
Clnr/Scav Tail	21.6	0.83	1.99	0.5	3.2
Pre-Cleaner Feed	100.0	25.9	13.00	100.0	100.0
Conc	77.3	32.9	16.1	98.2	95.6
Tail	22.7	2.03	2.49	1.8	4.4
Cleaner Feed	100.0	2.03	2.49	100.0	100.0
Conc	3.48	30.6	13.8	52.4	19.3
Tail	96.5	0.92	2.07	47.6	80.7
Clnr/Scav Feed	100.0	0.92	2.07	100.0	100.0
Conc	0.90	11.3	10.9	11.1	4.8
Tail	99.1	0.83	1.99	88.9	95.2

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	71.6	14.7	14.7	85.3
6	3,327	74.0	15.2	29.9	70.1
8	2,362	63.0	12.9	42.8	57.2
10	1,651	45.8	9.4	52.2	47.8
14	1,168	39.6	8.1	60.4	39.6
20	833	29.6	6.1	66.5	33.5
28	589	24.5	5.0	71.5	28.5
35	417	20.3	4.2	75.7	24.3
48	295	15.0	3.1	78.7	21.3
65	208	15.4	3.2	81.9	18.1
100	147	13.7	2.8	84.7	15.3
150	104	11.3	2.3	87.0	13.0
200	74	10.4	2.1	89.2	10.8
270	53	9.3	1.9	91.1	8.9
400	37	5.9	1.2	92.3	7.7
Pan	-37	37.5	7.7	100.0	-
Total	-	**486.9**	**100.0**	-	-
K80	**4,237**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	5.1	2.6	2.6	97.4
14	1,168	19.6	10.0	12.6	87.4
20	833	28.2	14.3	26.9	73.1
28	589	25.8	13.1	40.0	60.0
35	417	20.5	10.4	50.4	49.6
48	295	14.6	7.4	57.8	42.2
65	208	13.9	7.1	64.9	35.1
100	147	12.4	6.3	71.2	28.8
150	104	9.8	5.0	76.2	23.8
200	74	8.2	4.2	80.3	19.7
270	53	7.3	3.7	84.0	16.0
400	37	4.1	2.1	86.1	13.9
Pan	-37	27.3	13.9	100.0	-
Total	-	**196.8**	**100.0**	-	-
K80	**992**				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.6	3.1	3.1	96.9
14	1,168	16.5	7.6	10.7	89.3
20	833	24.3	11.3	22.0	78.0
28	589	30.5	14.1	36.1	63.9
35	417	28.9	13.4	49.5	50.5
48	295	21.4	9.9	59.4	40.6
65	208	16.5	7.6	67.0	33.0
100	147	14.4	6.7	73.7	26.3
150	104	11.0	5.1	78.8	21.2
200	74	8.7	4.0	82.8	17.2
270	53	7.2	3.3	86.2	13.8
400	37	5.2	2.4	88.6	11.4
Pan	-37	24.7	11.4	100.0	-
Total	-	215.9	100.0	-	-
K80	892				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	21.8	6.4	6.4	93.6
14	1,168	53.3	15.7	22.1	77.9
20	833	76.7	22.6	44.7	55.3
28	589	84.6	24.9	69.6	30.4
35	417	53.3	15.7	85.3	14.7
48	295	21.3	6.3	91.6	8.4
65	208	10.3	3.0	94.6	5.4
100	147	4.3	1.3	95.9	4.1
150	104	2.1	0.6	96.5	3.5
200	74	1.4	0.4	96.9	3.1
270	53	1.2	0.4	97.3	2.7
400	37	0.8	0.2	97.5	2.5
Pan	-37	8.4	2.5	100.0	-
Total	-	339.5	100.0	-	-
K80	1,244				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.5	2.7	2.7	97.3
14	1,168	11.7	7.1	9.9	90.1
20	833	17.2	10.5	20.3	79.7
28	589	20.7	12.6	32.9	67.1
35	417	20.3	12.3	45.3	54.7
48	295	15.6	9.5	54.7	45.3
65	208	14.8	9.0	63.7	36.3
100	147	10.8	6.6	70.3	29.7
150	104	8.9	5.4	75.7	24.3
200	74	7.3	4.4	80.2	19.8
270	53	5.9	3.6	83.8	16.2
400	37	4.7	2.9	86.6	13.4
Pan	-37	22.0	13.4	100.0	-
Total	-	**164.4**	**100.0**	-	-
K80	**849**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.6	1.1	1.1	98.9
100	147	2.8	2.0	3.2	96.8
150	104	7.6	5.4	8.6	91.4
200	74	16.7	12.0	20.6	79.4
270	53	24.6	17.6	38.2	61.8
400	37	21.9	15.7	53.9	46.1
Pan	-37	64.3	46.1	100.0	-
Total	-	**139.5**	**100.0**	-	-
K80	**77.6**				

Test No. PP-16

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	8.2	3.7	3.7	96.3
14	1,168	12.9	5.8	9.5	90.5
20	833	16.7	7.5	17.0	83.0
28	589	25.7	11.6	28.6	71.4
35	417	28.4	12.8	41.3	58.7
48	295	22.9	10.3	51.6	48.4
65	208	19.0	8.5	60.2	39.8
100	147	16.6	7.5	67.6	32.4
150	104	13.3	6.0	73.6	26.4
200	74	11.2	5.0	78.6	21.4
270	53	9.4	4.2	82.9	17.1
400	37	7.1	3.2	86.1	13.9
Pan	-37	31.0	13.9	100.0	-
Total	-	222.4	100.0	-	-
K80	763				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.1	0.9	0.9	99.1
35	417	14.4	11.2	12.0	88.0
48	295	14.6	11.3	23.4	76.6
65	208	12.6	9.8	33.2	66.8
100	147	15.9	12.4	45.5	54.5
150	104	12.1	9.4	54.9	45.1
200	74	10.2	7.9	62.9	37.1
270	53	9.3	7.2	70.1	29.9
400	37	5.5	4.3	74.4	25.6
Pan	-37	33.0	25.6	100.0	-
Total	-	128.7	100.0	-	-
K80	322				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.0	0.7	0.7	99.3
35	417	12.6	8.5	9.2	90.8
48	295	15.7	10.6	19.8	80.2
65	208	13.7	9.3	29.1	70.9
100	147	17.7	12.0	41.0	59.0
150	104	14.5	9.8	50.8	49.2
200	74	12.9	8.7	59.6	40.4
270	53	11.5	7.8	67.3	32.7
400	37	8.1	5.5	72.8	27.2
Pan	-37	40.2	27.2	100.0	-
Total	-	147.9	100.0	-	-
K80	290				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	1.2	4.5	4.5	95.5
100	147	0.3	1.1	5.7	94.3
150	104	0.3	1.1	6.8	93.2
200	74	0.4	1.5	8.3	91.7
270	53	0.5	1.9	10.2	89.8
400	37	0.2	0.8	10.9	89.1
Pan	-37	23.6	89.1	100.0	-
Total	-	26.5	100.0	-	-
K80					

Test No. PP-16

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.0	0.0	0.0	100.0
150	104	0.1	0.4	0.4	99.6
200	74	0.3	1.3	1.7	98.3
270	53	0.5	2.1	3.8	96.2
400	37	0.6	2.6	6.4	93.6
Pan	-37	21.9	93.6	100.0	-
Total	-	23.4	100.0	-	-
K80					

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	10.5	6.4	6.4	93.6
100	147	21.5	13.0	19.4	80.6
150	104	30.0	18.2	37.5	62.5
200	74	28.3	17.1	54.7	45.3
270	53	18.4	11.1	65.8	34.2
400	37	10.0	6.1	71.9	28.1
Pan	-37	46.5	28.1	100.0	-
Total	-	165.2	100.0	-	-
K80	145				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.6	0.8	0.8	99.2
35	417	22.6	11.5	12.3	87.7
48	295	24.9	12.6	24.9	75.1
65	208	17.2	8.7	33.7	66.3
100	147	23.6	12.0	45.7	54.3
150	104	18.9	9.6	55.3	44.7
200	74	15.8	8.0	63.3	36.7
270	53	13.3	6.8	70.0	30.0
400	37	10.3	5.2	75.3	24.7
Pan	-37	48.7	24.7	100.0	-
Total	-	196.9	100.0	-	-
K80	332				

Test No. PP-16

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 77.2 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	2.6	0.0	6.4	3.7	2.7
14	10.0	0.0	15.7	5.8	7.1
20	14.3	0.0	22.6	7.5	10.5
28	13.1	0.9	24.9	11.6	12.6
35	10.4	11.2	15.7	12.8	12.3
48	7.4	11.3	6.3	10.3	9.5
65	7.1	9.8	3.0	8.5	9.0
100	6.3	12.4	1.3	7.5	6.6
150	5.0	9.4	0.6	6.0	5.4
200	4.2	7.9	0.4	5.0	4.4
270	3.7	7.2	0.4	4.2	3.6
400	2.1	4.3	0.2	3.2	3.6
Pan	13.9	25.6	2.5	13.9	12.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	2.6	0.0
14	101 %	7.9	7.9
20	95 %	11.0	10.5
28	92 %	12.4	11.3
35	-26 %	9.6	-2.5
48	98 %	8.8	8.6
65	50 %	7.6	3.7
100	98 %	6.9	6.7
150	82 %	5.4	4.5
200	81 %	4.6	3.7
270	91 %	4.0	3.6
400	74 %	2.6	1.9
Pan	103 %	16.8	17.3
Total	**--**	**100.0**	**77.2 %**

Test No. PP-17

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Conc Grade	44.4 % Cu
Column Copper Rec'y	52.0 %

A series of column cell tests were conducted to examine the effects of gas rate, wash water rate and cell level. The main circuit once again suffered a number of plug-ups during the day and systematic shift samples were not taken. The individual column cell tests, however, were completed during periods of smooth operation in the main circuit.

Test PP-17 / PP-18 **Specials**

Test	Air set	Wash set	Depth cm	Product	Wt %	Assays		Distribution %	
						% Cu	% Fe	Cu	Fe
A	120 (med)	150 (high)	15 (low)	Feed	100.00	0.28	1.09	100.0	100.0
				Conc	0.11	44.4	20.6	18.0	2.1
				Tail	99.89	0.23	1.08	82.0	97.9
B	120 (med)	150 (high)	30 (med)	Feed	100.00	0.28	1.07	100.0	100.0
				Conc	0.32	44.4	19.8	50.2	5.9
				Tail	99.68	0.14	1.05	49.8	94.1
C	120 (med)	150 (high)	45 (high)	Feed	100.00	0.28	1.12	100.0	100.0
				Conc	0.20	44.9	20.0	32.3	3.6
				Tail	99.80	0.19	1.07	67.7	96.4
D	150 (high)	150 (high)	30 (med)	Feed	100.00	0.26	1.04	100.0	100.0
				Conc	0.16	44.4	19.7	27.0	3.0
				Tail	99.84	0.19	1.10	73.0	97.0
E	90 (low)	150 (high)	30 (med)	Feed	100.00	0.28	1.03	100.0	100.0
				Conc	0.15	45.5	19.8	25.1	3.0
				Tail	99.85	0.21	0.98	74.9	97.0
F (a)	120 (med)	125 (med)	30 (med)	Feed	100.00	0.27	1.06	100.0	100.0
				Conc	0.11	45.7	19.5	18.6	2.0
				Tail	99.89	0.22	0.98	81.4	98.0
F (b)	120 (med)	125 (med)	30 (med)	Feed	100.00	0.25	1.05	100.0	100.0
				Conc	0.29	41.6	19.6	48.2	5.4
				Tail	99.71	0.13	1.03	51.8	94.6
G	120 (med)	100 (low)	30 (med)	Feed	100.00	0.33	1.26	100.0	100.0
				Conc	0.39	41.1	19.6	48.7	6.1
				Tail	99.61	0.17	1.07	51.3	93.9

Test No. PP-18

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	35.2 %	-100 mesh
Rod Mill Feed Grade	0.41 %	Cu
Column Conc Grade	48.1 %	Cu
Column Copper Rec'y	41.3 %	
Flotation Feed Size	53.0 %	-100 mesh
Flotation Head Grade	0.24 %	Cu
Final Tails Grade	0.16 %	Cu
Flotation Copper Grade	35.5 %	Cu
Flotation Copper Rec'y	25.5 %	
Combined Grade	42.3 %	Cu
Combined Recovery	66.8 %	

The unit column was operated with higher gas rates, and this resulted in improved recovery with no loss in grade.
With the positive influence of the unit column in the circuit, overall grade and recovery were improved significantly from the previous run.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	185.3 kg/h	-1/4 inch	(Wet Sple 1146.0 g)
			(Dry Sple 1118.9 g)
Feed Rate:	180.9 kg/h	dry ore	(Moisture 2.36 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,297 kg in 7.00 hr	
	Sample	278 kg in 1.50 hr	
Rod Mill Discharge:	1,603 g/L		(59 % Sol at SG 2.75)
	58.1	% plus 48 mesh	
	28.4	% minus 100 mesh	
Input Power:	45.51	for 3 disc revolutions	
	0.85	kW (95% drive efficiency)	
Average Power:	0.81 kW	Gross	
	0.47 kW	No Load	
	0.34 kW	Net	
Net Power Usage:	1.86 kWh/t	of -1/4 inch feed	
K80 Feed:	3,328	microns	
K80 Product:	969	microns	
Work Index (metric):	12.6		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 47 % circ. load)
Feed Rate:	85.7	kg/h	
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,128 g/L		(18 % Sol at SG 2.75)
Ball Mill Discharge:	1,588 g/L		(58 % Sol at SG 2.75)
	25.7	% plus 48 mesh	
	49.7	% minus 100 mesh	
Input Power:	34.21	for 3 disc revolutions	
	1.14	kW (95% drive efficiency)	
Average Power:	1.08 kW	Gross	
	0.52 kW	No Load	
	0.56 kW	Net	
Net Power Usage:	6.50 kWh/t	of screen oversize	
K80 Feed:	1,231	microns	
K80 Product:	332	microns	
Work Index (metric):	24.6		

3.1.3. Overall Mill Report:

Net Power Usage:	8.36 kWh/t
K80 Feed:	3,328 microns
K80 Product:	332 microns
Work Index (metric):	22.3
Screen Undersize:	53.0 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	3,328	18.6
Rod Mill Discharge	969	28.4
Column Feed	~~831~~ 792	35.6
Column Conc	70	98.5
Column Tail	825	35.2
Ball Mill Feed	1,231	3.7
Ball Mill Discharge	362	49.7
Screen Undersize	332	53.0
Rougher Feed	295	59.0
Regrind Feed	~30	97.6
Regrind Discharge	~25	100.0
Final Concentrate	129	87.0
Final Tail	306	55.6

3.2. Reagent Additions:

Average Feed Rate: 0.181 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	12.0	3.98
	DF-250	0.10%	8.0	2.65
	Pine Oil	100%	5.0 dr	14.92
Rougher Feed	PAX	0.10%	7.0	2.32
Scavenger Feed	PAX	0.10%	12.0	3.98
	DF-250	0.10%	2.0	0.66
	Pine Oil	0.10%	2.0	0.66
Scavenger Cell 4	PAX	0.10%	8.0	2.65
	DF-250	0.10%	4.0	1.33
Total	**PAX**			**12.93**
	DF-250			**4.64**
	Pine Oil			**15.59**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,603			2.75
Ball Mill Discharge	1,588			
Screen Feed	1,183			
Screen Undersize	1,128			
Rougher Feed		8.00	12.5	
Pre-Cleaner Feed		8.00		
Cleaner Feed		8.00		
Scavenger Tail	1,140			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	266.6	1,183	15.5	2.6
Rougher	84	188.5	1,128	15.6	5.4
Scavenger	168	187.2	1,134	14.8	11.3
Pre-Cleaner*	7.7		measured	1.1	7.0
Cleaner*	7.7		measured	1.0	7.7
Clnr/Scav*	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.49	1.42	0.41	1.35	180.9
Rod Mill Discharge			0.41	1.35	180.3
Ball Mill Discharge	0.21	0.94	0.21	0.97	85.7
Column Feed	0.33	1.27	0.35	1.23	266.6
Column Conc	43.7	19.5	48.1	20.0	0.63
Column Tail (Scr Fd)	0.22	1.11	0.23	1.18	266.0
Screen Oversize	0.22	0.98	0.21	0.97	85.7
Screen Undersize	0.23	1.26	0.24	1.29	180.3
Rougher Feed	0.35	1.45	0.37	1.42	188.5
Rougher Conc	10.7	7.90	15.2	9.1	1.29
Rougher Tail	0.30	1.40	0.27	1.36	187.2
Scav Tail (final)	0.16	1.32	0.14	1.24	179.8
Scavenger Conc	4.15	4.82	3.44	4.39	7.49
Pre-Cleaner Feed	13.2	9.31	13.7	9.3	1.49
Pre-Cleaner Conc	36.8	20.0	35.5	18.8	0.51
Pre-Cleaner Tail	2.06	4.06	2.62	4.46	0.99
Cleaner Feed	2.65	5.04	2.62	4.46	0.99
Cleaner Conc	34.0	19.3	33.4	19.9	0.03
Cleaner Tail	1.56	4.06	1.77	4.04	0.96
Clnr-Scav Conc	14.7	11.6	4.91	10.81	0.21
Clnr-Scav Tail	1.40	3.90	0.71	0.23	0.75
Flotation Conc	35.8	19.2	35.4	18.8	0.53
Combined Conc			42.3	19.5	1.17

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.00	0.41	1.35	100.0	100.0
Combined Conc	0.64	42.3	19.5	66.8	9.3
Final Tail	99.36	0.136	1.24	33.2	90.7
Column Feed	147.39	0.35	1.23	124.6	133.9
Conc	0.35	48.1	20.0	41.3	5.2
Tail	147.04	0.23	1.18	83.3	128.7
Flotation Feed	99.65	0.24	1.29	58.6	94.9
Conc	0.29	35.4	18.8	25.5	4.1
Tail	99.36	0.14	1.24	33.1	90.8
Rougher Feed	104.21	0.37	1.42	94.5	109.0
Conc	0.71	15.2	9.07	26.4	4.8
Tail	103.49	0.27	1.36	68.1	104.2
Scavenger Feed	103.49	0.27	1.36	68.0	104.2
Conc	4.14	3.44	4.39	34.9	13.4
Tail	99.36	0.136	1.24	33.1	90.8
Combined Clnr Feed	0.71	15.2	9.07	26.4	4.8
Flotation Conc	0.29	35.4	18.8	25.5	4.1
Clnr/Scav Tail	0.42	0.71	0.23	1.0	0.7
Pre-Cleaner Feed	0.83	13.7	9.31	27.8	5.7
Conc	0.28	35.5	18.8	24.3	3.9
Tail	0.55	2.62	4.46	3.5	1.8
Cleaner Feed	0.55	2.62	4.46	3.5	1.8
Conc	0.02	33.4	19.9	1.2	0.2
Tail	0.53	1.77	4.04	2.3	1.6
Clnr/Scav Feed	0.53	1.77	4.04	2.3	1.6
Conc	0.11	4.91	10.81	1.4	0.9
Tail	0.42	0.71	0.23	0.9	0.7

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.41	1.35	100.0	100.0
Combined Conc	0.64	42.3	19.5	66.8	9.3
Final Tail	99.4	0.136	1.24	33.2	90.7
Column Feed	100.0	0.35	1.23	100.0	100.0
Conc	0.24	48.1	20.0	33.1	3.9
Tail	99.8	0.23	1.18	66.9	96.1
Flotation Feed	100.0	0.24	1.29	100.0	100.0
Conc	0.30	35.4	18.8	43.5	4.3
Tail	99.7	0.14	1.24	56.5	95.7
Rougher Feed	100.0	0.37	1.42	100.0	100.0
Conc	0.68	15.2	9.1	28.0	4.4
Tail	99.3	0.27	1.36	72.0	95.6
Scavenger Feed	100.0	0.27	1.36	100.0	100.0
Conc	4.0	3.44	4.39	51.4	12.9
Tail	96.0	0.136	1.24	48.6	87.1
Combined Clnr Feed	100.0	15.2	9.1	100.0	100.0
Flotation Conc	41.4	35.4	18.8	96.3	85.9
Clnr/Scav Tail	58.6	0.71	0.23	3.7	14.1
Pre-Cleaner Feed	100.0	13.7	9.31	100.0	100.0
Conc	33.9	35.5	18.8	87.5	68.4
Tail	66.1	2.62	4.46	12.5	31.6
Cleaner Feed	100.0	2.62	4.46	100.0	100.0
Conc	2.75	33.4	19.9	35.1	12.2
Tail	97.3	1.77	4.04	64.9	87.8
Clnr/Scav Feed	100.0	1.77	4.04	100.0	100.0
Conc	21.47	4.9	10.8	59.7	57.5
Tail	78.5	0.71	0.23	40.3	42.5

5. Screen Analyses: Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	71.1	8.5	8.5	91.5
6	3,327	96.5	11.5	20.0	80.0
8	2,362	91.3	10.9	30.9	69.1
10	1,651	85.2	10.2	41.0	59.0
14	1,168	77.8	9.3	50.3	49.7
20	833	60.3	7.2	57.5	42.5
28	589	55.5	6.6	64.1	35.9
35	417	47.0	5.6	69.7	30.3
48	295	36.2	4.3	74.0	26.0
65	208	32.6	3.9	77.9	22.1
100	147	29.5	3.5	81.4	18.6
150	104	25.4	3.0	84.5	15.5
200	74	23.8	2.8	87.3	12.7
270	53	20.7	2.5	89.8	10.2
400	37	15.0	1.8	91.6	8.4
Pan	-37	70.8	8.4	100.0	-
Total	-	**838.7**	**100.0**	-	-
K80	**3,328**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.3	2.1	2.1	97.9
14	1,168	27.3	9.2	11.4	88.6
20	833	43.4	14.7	26.0	74.0
28	589	40.3	13.6	39.7	60.3
35	417	31.9	10.8	50.4	49.6
48	295	22.8	7.7	58.1	41.9
65	208	21.2	7.2	65.3	34.7
100	147	18.5	6.3	71.6	28.4
150	104	15.0	5.1	76.6	23.4
200	74	12.7	4.3	80.9	19.1
270	53	10.8	3.7	84.6	15.4
400	37	8.2	2.8	87.4	12.6
Pan	-37	37.4	12.6	100.0	-
Total	-	**295.8**	**100.0**	-	-
K80	**969**				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.7	1.3	1.3	98.7
14	1,168	17.8	6.4	7.8	92.2
20	833	28.9	10.5	18.2	81.8
28	589	31.1	11.3	29.5	70.5
35	417	27.9	10.1	39.6	60.4
48	295	24.0	8.7	48.3	51.7
65	208	22.6	8.2	56.5	43.5
100	147	21.9	7.9	64.4	35.6
150	104	18.4	6.7	71.0	29.0
200	74	15.4	5.6	76.6	23.4
270	53	13.1	4.7	81.4	18.6
400	37	10.4	3.8	85.1	14.9
Pan	-37	41.1	14.9	100.0	-
Total	-	**276.3**	**100.0**	-	-
K80	**792**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.8	0.4	0.4	99.6
100	147	2.1	1.1	1.5	98.5
150	104	7.3	3.9	5.4	94.6
200	74	20.8	11.1	16.5	83.5
270	53	35.3	18.8	35.3	64.7
400	37	32.6	17.3	52.6	47.4
Pan	-37	89.1	47.4	100.0	-
Total	-	**188.0**	**100.0**	-	-
K80	**69.8**				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.5	1.5	1.5	98.5
14	1,168	15.6	6.8	8.4	91.6
20	833	25.9	11.3	19.7	80.3
28	589	26.5	11.6	31.3	68.7
35	417	23.1	10.1	41.4	58.6
48	295	19.0	8.3	49.7	50.3
65	208	18.1	7.9	57.6	42.4
100	147	16.5	7.2	64.8	35.2
150	104	14.3	6.3	71.1	28.9
200	74	12.4	5.4	76.5	23.5
270	53	10.7	4.7	81.2	18.8
400	37	8.6	3.8	85.0	15.0
Pan	-37	34.4	15.0	100.0	-
Total	-	**228.6**	**100.0**	-	-
K80	**825**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	17.7	4.7	4.7	95.3
14	1,168	60.5	16.2	21.0	79.0
20	833	98.8	26.5	47.5	52.5
28	589	100.5	27.0	74.4	25.6
35	417	49.8	13.4	87.8	12.2
48	295	18.1	4.9	92.6	7.4
65	208	9.4	2.5	95.1	4.9
100	147	4.4	1.2	96.3	3.7
150	104	2.3	0.6	96.9	3.1
200	74	1.7	0.5	97.4	2.6
270	53	1.5	0.4	97.8	2.2
400	37	1.0	0.3	98.1	1.9
Pan	-37	7.2	1.9	100.0	-
Total	-	**372.9**	**100.0**	-	-
K80	**1,231**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.0	0.4	0.4	99.6
14	1,168	2.6	0.9	1.3	98.7
20	833	5.9	2.1	3.4	96.6
28	589	13.2	4.7	8.0	92.0
35	417	22.8	8.0	16.1	83.9
48	295	27.3	9.6	25.7	74.3
65	208	35.9	12.7	38.4	61.6
100	147	33.9	12.0	50.3	49.7
150	104	27.6	9.7	60.1	39.9
200	74	23.6	8.3	68.4	31.6
270	53	20.0	7.1	75.4	24.6
400	37	14.5	5.1	80.6	19.4
Pan	-37	55.1	19.4	100.0	-
Total	-	283.4	100.0	-	-
K80	362				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	3.1	1.2	1.2	98.8
35	417	29.1	11.6	12.9	87.1
48	295	29.3	11.7	24.6	75.4
65	208	23.3	9.3	33.9	66.1
100	147	32.7	13.1	47.0	53.0
150	104	24.4	9.8	56.8	43.2
200	74	20.9	8.4	65.2	34.8
270	53	17.8	7.1	72.3	27.7
400	37	13.2	5.3	77.6	22.4
Pan	-37	56.0	22.4	100.0	-
Total	-	249.8	100.0	-	-
K80	332				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.5	0.9	0.9	99.1
35	417	12.9	7.6	8.5	91.5
48	295	21.7	12.8	21.2	78.8
65	208	13.9	8.2	29.4	70.6
100	147	19.7	11.6	41.0	59.0
150	104	16.7	9.8	50.8	49.2
200	74	14.8	8.7	59.5	40.5
270	53	12.9	7.6	67.1	32.9
400	37	10.2	6.0	73.1	26.9
Pan	-37	45.7	26.9	100.0	-
Total	-	**170.0**	**100.0**	-	-
K80	**295**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	0.2	1.6	1.6	98.4
100	147	0.1	0.8	2.4	97.6
150	104	0.2	1.6	4.0	96.0
200	74	0.2	1.6	5.6	94.4
270	53	0.4	3.2	8.8	91.2
400	37	0.3	2.4	11.2	88.8
Pan	-37	11.1	88.8	100.0	-
Total	-	**12.5**	**100.0**	-	-
K80					

Test No. PP-18

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.0	0.0	0.0	100.0
150	104	0.2	1.3	1.3	98.7
200	74	0.2	1.3	2.5	97.5
270	53	0.3	1.9	4.5	95.5
400	37	0.6	3.8	8.3	91.7
Pan	-37	14.4	91.7	100.0	-
Total	-	15.7	100.0	-	-
K80					

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.7	3.1	3.1	96.9
100	147	8.7	9.9	13.0	87.0
150	104	15.1	17.2	30.2	69.8
200	74	15.6	17.8	47.9	52.1
270	53	11.9	13.6	61.5	38.5
400	37	6.9	7.9	69.4	30.6
Pan	-37	26.9	30.6	100.0	-
Total	-	87.8	100.0	-	-
K80	129				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.9	0.9	0.9	99.1
35	417	15.4	7.5	8.4	91.6
48	295	29.5	14.3	22.8	77.2
65	208	18.1	8.8	31.6	68.4
100	147	26.4	12.8	44.4	55.6
150	104	20.5	10.0	54.4	45.6
200	74	17.4	8.5	62.8	37.2
270	53	15.4	7.5	70.3	29.7
400	37	10.8	5.3	75.6	24.4
Pan	-37	50.2	24.4	100.0	-
Total	-	205.6	100.0	-	-
K80	306				

Test No. PP-18

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 46.6 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	2.1	0.0	4.7	0.4	1.3
14	9.2	0.0	16.2	0.9	6.4
20	14.7	0.0	26.5	2.1	10.5
28	13.6	1.2	27.0	4.7	11.3
35	10.8	11.6	13.4	8.0	10.1
48	7.7	11.7	4.9	9.6	8.7
65	7.2	9.3	2.5	12.7	8.2
100	6.3	13.1	1.2	12.0	7.9
150	5.1	9.8	0.6	9.7	6.7
200	4.3	8.4	0.5	8.3	5.6
270	3.7	7.1	0.4	7.1	4.7
400	2.8	5.3	0.3	5.1	4.7
Pan	12.6	22.4	1.9	19.4	13.9
Total	100.0	100.0	100.0	100.0	100.0

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	2.1	0.0
14	60 %	6.1	3.7
20	60 %	9.9	6.0
28	56 %	10.4	5.8
35	-16 %	11.3	-1.8
48	84 %	8.6	7.2
65	21 %	8.1	1.7
100	63 %	8.5	5.4
150	51 %	6.7	3.4
200	52 %	5.7	2.9
270	52 %	4.8	2.5
400	52 %	3.6	1.9
Pan	56 %	14.2	7.9
Total	--	100.0	46.6 %

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	34.7 % -100 mesh
Rod Mill Feed Grade	0.32 % Cu
Column Conc Grade	43.2 % Cu
Column Copper Rec'y	26.8 %
Flotation Feed Size	60.1 % -100 mesh
Flotation Head Grade	0.24 % Cu
Final Tails Grade	0.12 % Cu
Flotation Copper Grade	34.2 % Cu
Flotation Copper Rec'y	37.4 %
Combined Grade	37.5 % Cu
Combined Recovery	64.2 %

No significant changes were made in the operation of the circuit, but the new feed grade dropped to 0.32 %Cu. The lower feed grade appeared to have a detrimental effect on the operation of the unit column, and the overall performance of the circuit was generally poorer.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed: 193.4 kg/h -1/4 inch (Wet Sple 1174.9 g)
(Dry Sple 1156.5 g)
Feed Rate: 190.4 kg/h dry ore (Moisture 1.57 %)
Mill Speed: 45 RPM (85% of critical speed)
Rod Load: 100 kg
Rod Mill Feed: Total 1,064 kg in 5.50 hr
Sample 193 kg in 1.00 hr
Rod Mill Discharge: 1,647 g/L (62 % Sol at SG 2.75)
60.9 % plus 48 mesh
26.9 % minus 100 mesh
Input Power: 48.65 for 3 disc revolutions
0.80 kW (95% drive efficiency)
Average Power: 0.76 kW Gross
0.47 kW No Load
0.29 kW Net
Net Power Usage: 1.50 kWh/t of -1/4 inch feed
K80 Feed: 4,467 microns
K80 Product: 1,128 microns
Work Index (metric): 10.1

3.1.2. Ball Mill Report:

Feed: Screen Oversize (at 64 % circ. load)
Feed Rate: 122.3 kg/h
Mill Speed: 40 RPM (77% of critical speed)
Ball Load: 150 kg
Screen Undersize: 1,157 g/L (21 % Sol at SG 2.75)
Ball Mill Discharge: 1,610 g/L (60 % Sol at SG 2.75)
32.1 % plus 48 mesh
46.0 % minus 100 mesh
Input Power: 35.88 for 3 disc revolutions
1.08 kW (95% drive efficiency)
Average Power: 1.03 kW Gross
0.52 kW No Load
0.51 kW Net
Net Power Usage: 4.14 kWh/t of screen oversize
K80 Feed: 1,128 microns
K80 Product: 266 microns
Work Index (metric): 13.1

3.1.3. Overall Mill Report:

Net Power Usage:	5.64 kWh/t
K80 Feed:	4,467 microns
K80 Product:	266 microns
Work Index (metric):	12.2
Screen Undersize:	60.1 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	4,467	13.0
Rod Mill Discharge	1,128	26.9
Column Feed	835	34.7
Column Conc	80	97.3
Column Tail	938	30.0
Ball Mill Feed	1,427	3.3
Ball Mill Discharge	444	46.0
Screen Undersize	266	60.1
Rougher Feed	250	62.2
Regrind Feed	~30	92.3
Regrind Discharge	~25	97.9
Final Concentrate	132	85.7
Final Tail	287	55.6

3.2. Reagent Additions:

Average Feed Rate: 0.190 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	12.0	3.78
	DF-250	0.10%	8.0	2.52
	Pine Oil	100%	5.0 dr	14.18
Rougher Feed	PAX	0.10%	7.0	2.21
Scavenger Feed	PAX	0.10%	12.0	3.78
	DF-250	0.10%	2.0	0.63
	Pine Oil	0.10%	2.0	0.63
Scavenger Cell 4	PAX	0.10%	8.0	2.52
	DF-250	0.10%	4.0	1.26
Total	**PAX**			**12.29**
	DF-250			**4.41**
	Pine Oil			**14.81**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,647			2.75
Ball Mill Discharge	1,610			
Screen Feed	1,290			
Screen Undersize	1,157			
Rougher Feed		7.80	16.0	
Pre-Cleaner Feed		7.80		
Cleaner Feed		7.80		
Scavenger Tail	1,193			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	312.7	1,290	11.4	3.5
Rougher	84	196.1	1,157	13.2	6.3
Scavenger	168	195.0	1,175	11.8	14.2
Pre-Cleaner*	7.7		measured	1.1	7.0
Cleaner*	7.7		measured	1.0	7.7
Clnr/Scav*	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.33	1.55	0.32	1.52	190.4
Rod Mill Discharge			0.32	1.52	190.4
Ball Mill Discharge	0.17	0.98	0.17	0.91	122.3
Column Feed	0.29	1.28	0.26	1.28	312.7
Column Conc	42.6	19.9	43.2	19.9	0.38
Column Tail (Scr Fd)	0.24	1.20	0.21	1.26	312.3
Screen Oversize	0.16	0.92	0.26	1.28	122.3
Screen Undersize	0.22	1.48	0.24	1.48	190.0
Rougher Feed	0.24	1.64	0.29	1.55	196.1
Rougher Conc	11.0	8.34	22.8	9.08	1.02
Rougher Tail	0.19	1.56	0.17	1.51	195.0
Scav Tail (final)	0.13	1.58	0.12	1.44	189.3
Scavenger Conc	2.12	3.73	2.04	3.79	5.73
Pre-Cleaner Feed	8.85	7.34	22.7	9.1	1.03
Pre-Cleaner Conc	35.7	19.4	34.3	12.5	0.67
Pre-Cleaner Tail	1.89	4.28	1.22	2.77	0.36
Cleaner Feed	1.66	4.63	1.22	2.77	0.36
Cleaner Conc	23.9	16.0	24.0	15.9	0.00
Cleaner Tail	1.24	4.24	1.10	2.70	0.36
Clnr-Scav Conc	11.9	11.4	12.25	11.41	0.00
Clnr-Scav Tail	0.93	4.29	0.98	2.61	0.35
Flotation Conc	35.6	19.2	34.2	12.5	0.67
Combined Conc			37.5	15.2	1.05

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays Cu	Assays Fe	Distributions (%) Cu	Distributions (%) Fe
Rod Mill Feed	100.00	0.32	1.52	100.0	100.0
Combined Conc	0.55	37.5	15.2	64.2	5.5
Final Tail	99.45	0.116	1.44	35.8	94.5
Column Feed	164.26	0.26	1.28	133.7	138.7
Conc	0.20	43.2	19.9	26.8	2.6
Tail	164.06	0.21	1.26	107.0	136.1
Flotation Feed	99.80	0.24	1.48	73.2	97.4
Conc	0.35	34.2	12.5	37.4	2.9
Tail	99.45	0.12	1.44	35.8	94.5
Rougher Feed	103.00	0.29	1.55	92.8	105.2
Conc	0.54	22.8	9.08	38.0	3.2
Tail	102.46	0.17	1.51	54.8	102.0
Scavenger Feed	102.46	0.17	1.51	54.9	102.0
Conc	3.01	2.04	3.79	19.0	7.5
Tail	99.45	0.116	1.44	35.9	94.5
Combined Clnr Feed	0.54	22.8	9.08	38.0	3.2
Flotation Conc	0.35	34.2	12.5	37.4	2.9
Clnr/Scav Tail	0.19	0.98	2.61	0.5	0.3
Pre-Cleaner Feed	0.54	22.7	9.09	38.0	3.2
Conc	0.35	34.3	12.5	37.3	2.9
Tail	0.19	1.22	2.77	0.7	0.3
Cleaner Feed	0.19	1.22	2.77	0.7	0.3
Conc	0.00	24.0	15.9	0.1	0.0
Tail	0.19	1.10	2.70	0.6	0.3
Clnr/Scav Feed	0.19	1.10	2.70	0.6	0.3
Conc	0.00	12.25	11.41	0.1	0.0
Tail	0.19	0.98	2.61	0.6	0.3

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.32	1.52	100.0	100.0
Combined Conc	0.55	37.5	15.2	64.2	5.5
Final Tail	99.4	0.116	1.44	35.8	94.5
Column Feed	100.0	0.26	1.28	100.0	100.0
Conc	0.12	43.2	19.9	20.0	1.9
Tail	99.9	0.21	1.26	80.0	98.1
Flotation Feed	100.0	0.24	1.48	100.0	100.0
Conc	0.35	34.2	12.5	51.1	3.0
Tail	99.6	0.12	1.44	48.9	97.0
Rougher Feed	100.0	0.29	1.55	100.0	100.0
Conc	0.52	22.8	9.1	40.9	3.1
Tail	99.5	0.17	1.51	59.1	96.9
Scavenger Feed	100.0	0.17	1.51	100.0	100.0
Conc	2.9	2.04	3.79	34.6	7.4
Tail	97.1	0.116	1.44	65.4	92.6
Combined Clnr Feed	100.0	22.8	9.1	100.0	100.0
Flotation Conc	65.6	34.2	12.5	98.6	90.2
Clnr/Scav Tail	34.4	0.98	2.61	1.4	9.8
Pre-Cleaner Feed	100.0	22.7	9.09	100.0	100.0
Conc	65.2	34.3	12.5	98.2	89.4
Tail	34.8	1.22	2.77	1.8	10.6
Cleaner Feed	100.0	1.22	2.77	100.0	100.0
Conc	0.53	24.0	15.9	10.5	3.1
Tail	99.5	1.10	2.70	89.5	96.9
Clnr/Scav Feed	100.0	1.10	2.70	100.0	100.0
Conc	1.07	12.3	11.4	12.0	4.5
Tail	98.9	0.98	2.61	88.0	95.5

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	93.7	16.5	16.5	83.5
6	3,327	102.2	18.0	34.6	65.4
8	2,362	74.9	13.2	47.8	52.2
10	1,651	54.3	9.6	57.4	42.6
14	1,168	44.0	7.8	65.2	34.8
20	833	31.7	5.6	70.8	29.2
28	589	25.6	4.5	75.3	24.7
35	417	20.8	3.7	79.0	21.0
48	295	15.6	2.8	81.7	18.3
65	208	15.3	2.7	84.4	15.6
100	147	14.3	2.5	87.0	13.0
150	104	12.4	2.2	89.1	10.9
200	74	11.6	2.0	91.2	8.8
270	53	10.3	1.8	93.0	7.0
400	37	7.8	1.4	94.4	5.6
Pan	-37	31.8	5.6	100.0	-
Total	-	566.3	100.0	-	-
K80	4,467				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	11.5	5.7	5.7	94.3
14	1,168	26.1	12.8	18.5	81.5
20	833	27.5	13.5	32.0	68.0
28	589	24.5	12.0	44.1	55.9
35	417	19.5	9.6	53.6	46.4
48	295	14.8	7.3	60.9	39.1
65	208	12.6	6.2	67.1	32.9
100	147	12.1	5.9	73.1	26.9
150	104	9.7	4.8	77.8	22.2
200	74	8.6	4.2	82.1	17.9
270	53	7.6	3.7	85.8	14.2
400	37	5.9	2.9	88.7	11.3
Pan	-37	23.0	11.3	100.0	-
Total	-	203.4	100.0	-	-
K80	1,128				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	8.5	3.6	3.6	96.4
14	1,168	19.6	8.2	11.8	88.2
20	833	23.3	9.8	21.6	78.4
28	589	23.3	9.8	31.3	68.7
35	417	22.7	9.5	40.9	59.1
48	295	19.5	8.2	49.1	50.9
65	208	19.6	8.2	57.3	42.7
100	147	19.2	8.1	65.3	34.7
150	104	15.2	6.4	71.7	28.3
200	74	12.4	5.2	76.9	23.1
270	53	10.7	4.5	81.4	18.6
400	37	7.7	3.2	84.6	15.4
Pan	-37	36.6	15.4	100.0	-
Total	-	**238.3**	**100.0**	-	-
K80	**880**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.2	0.8	0.8	99.2
100	147	2.8	1.9	2.7	97.3
150	104	9.0	6.2	8.9	91.1
200	74	19.5	13.4	22.3	77.7
270	53	26.9	18.4	40.7	59.3
400	37	23.9	16.4	57.1	42.9
Pan	-37	62.6	42.9	100.0	-
Total	-	**145.9**	**100.0**	-	-
K80	**80.1**				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	15.3	4.3	4.3	95.7
14	1,168	32.7	9.1	13.4	86.6
20	833	36.7	10.2	23.6	76.4
28	589	37.9	10.5	34.1	65.9
35	417	37.7	10.5	44.6	55.4
48	295	31.9	8.9	53.5	46.5
65	208	31.3	8.7	62.2	37.8
100	147	27.9	7.8	70.0	30.0
150	104	20.6	5.7	75.7	24.3
200	74	16.5	4.6	80.3	19.7
270	53	13.8	3.8	84.1	15.9
400	37	10.1	2.8	86.9	13.1
Pan	-37	46.9	13.1	100.0	-
Total	-	**359.3**	**100.0**	-	-
K80	**938**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	27.7	11.0	11.0	89.0
14	1,168	53.7	21.3	32.3	67.7
20	833	57.2	22.7	55.0	45.0
28	589	56.5	22.4	77.4	22.6
35	417	30.3	12.0	89.4	10.6
48	295	11.0	4.4	93.8	6.2
65	208	5.0	2.0	95.8	4.2
100	147	2.3	0.9	96.7	3.3
150	104	1.3	0.5	97.2	2.8
200	74	1.0	0.4	97.6	2.4
270	53	1.0	0.4	98.0	2.0
400	37	0.9	0.4	98.3	1.7
Pan	-37	4.2	1.7	100.0	-
Total	-	**252.1**	**100.0**	-	-
K80	**1,427**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.5	0.8	0.8	99.2
14	1,168	6.1	1.9	2.7	97.3
20	833	10.5	3.3	5.9	94.1
28	589	20.4	6.4	12.3	87.7
35	417	30.0	9.3	21.6	78.4
48	295	33.5	10.4	32.1	67.9
65	208	35.4	11.0	43.1	56.9
100	147	34.9	10.9	54.0	46.0
150	104	29.0	9.0	63.0	37.0
200	74	24.3	7.6	70.6	29.4
270	53	20.7	6.4	77.0	23.0
400	37	16.1	5.0	82.0	18.0
Pan	-37	57.7	18.0	100.0	-
Total	-	**321.1**	**100.0**	-	-
K80	**444**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.3	0.6	0.6	99.4
35	417	14.3	6.8	7.4	92.6
48	295	19.5	9.3	16.7	83.3
65	208	22.9	10.9	27.6	72.4
100	147	25.7	12.2	39.9	60.1
150	104	22.3	10.6	50.5	49.5
200	74	19.6	9.3	59.8	40.2
270	53	17.0	8.1	67.9	32.1
400	37	13.0	6.2	74.1	25.9
Pan	-37	54.4	25.9	100.0	-
Total	-	**210.0**	**100.0**	-	-
K80	**266**				

Test No. PP-19

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.8	0.5	0.5	99.5
35	417	9.1	6.2	6.7	93.3
48	295	12.3	8.3	15.1	84.9
65	208	15.0	10.2	25.2	74.8
100	147	18.5	12.6	37.8	62.2
150	104	15.7	10.7	48.4	51.6
200	74	14.2	9.6	58.1	41.9
270	53	12.7	8.6	66.7	33.3
400	37	9.7	6.6	73.3	26.7
Pan	-37	39.4	26.7	100.0	-
Total	-	**147.4**	**100.0**	-	-
K80	**250**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	1.2	6.6	6.6	93.4
100	147	0.2	1.1	7.7	92.3
150	104	0.1	0.5	8.2	91.8
200	74	0.3	1.6	9.9	90.1
270	53	0.4	2.2	12.1	87.9
400	37	0.4	2.2	14.3	85.7
Pan	-37	15.6	85.7	100.0	-
Total	-	**18.2**	**100.0**	-	-
K80					

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.2	1.0	1.0	99.0
100	147	0.2	1.0	2.1	97.9
150	104	0.3	1.6	3.6	96.4
200	74	0.5	2.6	6.2	93.8
270	53	0.7	3.6	9.8	90.2
400	37	0.9	4.7	14.5	85.5
Pan	-37	16.5	85.5	100.0	-
Total	-	19.3	100.0	-	-
K80					

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.9	3.4	3.4	96.6
100	147	9.1	10.8	14.3	85.7
150	104	14.6	17.3	31.6	68.4
200	74	13.8	16.4	48.0	52.0
270	53	10.6	12.6	60.6	39.4
400	37	6.5	7.7	68.3	31.7
Pan	-37	26.7	31.7	100.0	-
Total	-	84.2	100.0	-	-
K80	132				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.3	0.8	0.8	99.2
35	417	12.6	7.7	8.5	91.5
48	295	17.1	10.5	19.1	80.9
65	208	20.9	12.8	31.9	68.1
100	147	20.3	12.5	44.4	55.6
150	104	16.9	10.4	54.8	45.2
200	74	13.9	8.5	63.3	36.7
270	53	11.4	7.0	70.3	29.7
400	37	8.3	5.1	75.4	24.6
Pan	-37	40.0	24.6	100.0	-
Total	-	162.7	100.0	-	-
K80	287				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 66.7 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	5.7	0.0	11.0	0.8	3.6
14	12.8	0.0	21.3	1.9	8.2
20	13.5	0.0	22.7	3.3	9.8
28	12.0	0.6	22.4	6.4	9.8
35	9.6	6.8	12.0	9.3	9.5
48	7.3	9.3	4.4	10.4	8.2
65	6.2	10.9	2.0	11.0	8.2
100	5.9	12.2	0.9	10.9	8.1
150	4.8	10.6	0.5	9.0	6.4
200	4.2	9.3	0.4	7.6	5.2
270	3.7	8.1	0.4	6.4	4.5
400	2.9	6.2	0.4	5.0	4.5
Pan	11.3	25.9	1.7	18.0	14.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	5.7	0.0
14	66 %	8.5	5.6
20	70 %	9.3	6.5
28	71 %	9.7	6.9
35	104 %	9.5	9.8
48	33 %	8.1	2.7
65	52 %	7.8	4.1
100	63 %	7.9	5.0
150	69 %	6.5	4.5
200	71 %	5.6	4.0
270	72 %	4.9	3.5
400	71 %	3.8	2.7
Pan	90 %	12.9	11.5
Total	--	**100.0**	**66.7 %**

Test No. PP-20

1. **Purpose:** To operate the circuit at high circulating load. The column was not operated.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Flotation Feed Size	57.1 % -100 mesh
Flotation Head Grade	0.34 % Cu
Final Tails Grade	0.13 % Cu
Flotation Copper Grade	41.0 % Cu
Flotation Copper Rec'y	47.7 %

The purpose of this test was to attempt to operate the circuit with a very high circulating load. The circulating load was in fact increased from about 75% to about 300%. Operation of the already over-taxed grinding circuit at this very high rate required that all parts of the grinding circuit be observed closely and continuously. Although there were several "near misses", the circuit was operated without upset.

Concentrate grade was slightly below target, but recovery was very low at 56%.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	190.5 kg/h	-1/4 inch	(Wet Sple 1213.1 g)
			(Dry Sple 1191.2 g)
Feed Rate:	187.1 kg/h	dry ore	(Moisture 1.81 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	1,334 kg in 7.00 hr	
	Sample	381 kg in 2.00 hr	
Rod Mill Discharge:	1,606 g/L		(59 % Sol at SG 2.75)
	59.5	% plus 48 mesh	
	27.4	% minus 100 mesh	
Input Power:	47.13	for 3 disc revolutions	
	0.82	kW (95% drive efficiency)	
Average Power:	0.78 kW	Gross	
	0.47 kW	No Load	
	0.31 kW	Net	
Net Power Usage:	1.65 kWh/t	of -1/4 inch feed	
K80 Feed:	4,094	microns	
K80 Product:	992	microns	
Work Index (metric):	10.3		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 305 % circ. load)
Feed Rate:	570.5 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,153 g/L		(21 % Sol at SG 2.75)
Ball Mill Discharge:	1,768 g/L		(68 % Sol at SG 2.75)
	61.0	% plus 48 mesh	
	26.8	% minus 100 mesh	
Input Power:	32.82	for 3 disc revolutions	
	1.18	kW (95% drive efficiency)	
Average Power:	1.13 kW	Gross	
	0.52 kW	No Load	
	0.60 kW	Net	
Net Power Usage:	1.06 kWh/t	of screen oversize	
K80 Feed:	1,277	microns	
K80 Product:	373	microns	
Work Index (metric):	4.4		

3.1.3. Overall Mill Report:

Net Power Usage:	2.71 kWh/t
K80 Feed:	4,094 microns
K80 Product:	373 microns
Work Index (metric):	7.5
Screen Undersize:	50.9 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,094	15.4
Rod Mill Discharge	992	27.4
Ball Mill Feed	1,227	3.4
Ball Mill Discharge	999	26.8
Screen Undersize	373	50.9
Rougher Feed	326	53.0
Regrind Feed	150	79.7
Regrind Discharge	52.3	91.9
Final Concentrate	129	84.9
Final Tail	370	45.5

3.2. Reagent Additions:

Average Feed Rate: 0.187 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	12.0	3.85
	DF-250	0.10%	8.0	2.57
	Pine Oil	100%	4.6 dr	13.28
Rougher Feed	PAX	0.10%	7.5	2.41
Scavenger Feed	PAX	0.10%	12.0	3.85
	DF-250	0.10%	2.0	0.64
	Pine Oil	0.10%	2.0	0.64
Scavenger Cell 4	PAX	0.10%	8.0	2.57
	DF-250	0.10%	3.9	1.25
Total	**PAX**			**12.67**
	DF-250			**4.46**
	Pine Oil			**13.92**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,606			2.75
Ball Mill Discharge	1,768			
Screen Feed	1,218			
Screen Undersize	1,153			
Rougher Feed		8.00	16.0	
Pre-Cleaner Feed		8.00		
Cleaner Feed		8.00		
Scavenger Tail	1,185			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Rougher	84	200.0	1,153	13.9	6.1
Scavenger	168	197.2	1,169	12.4	13.6
Pre-Cleaner*	7.7		measured	1.1	7.0
Cleaner*	7.7		measured	1.0	7.7
Clnr/Scav*	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.46	1.44	0.41	1.46	187.1
Rod Mill Discharge			0.41	1.46	187.1
Ball Mill Discharge	0.17	0.79	0.16	0.81	570.5
Screen Feed	0.25	1.07	0.22	0.97	757.5
Screen Oversize	0.14	0.74	0.16	0.81	570.5
Screen Undersize	0.37	1.45	0.34	1.46	187.1
Rougher Feed	0.46	1.53	0.51	1.60	200.0
Rougher Conc	15.0	9.24	16.2	9.5	2.77
Rougher Tail	0.29	1.48	0.29	1.49	197.2
Scav Tail (final)	0.18	1.49	0.18	1.36	186.0
Scavenger Conc	2.08	3.74	2.02	3.69	11.28
Pre-Cleaner Feed	15.3	9.61	15.9	9.3	2.92
Pre-Cleaner Conc	39.8	19.5	39.7	19.3	1.03
Pre-Cleaner Tail	2.88	4.51	3.01	3.85	1.89
Cleaner Feed	2.81	4.91	3.01	3.85	1.89
Cleaner Conc	28.4	16.0	28.3	16.1	0.07
Cleaner Tail	1.95	4.39	1.99	3.36	1.82
Clnr-Scav Conc	10.6	9.34	10.38	4.63	0.15
Clnr-Scav Tail	1.33	4.20	1.24	3.24	1.67
Final Conc	39.0	19.2	39.0	19.1	1.10

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.00	0.41	1.46	100.0	100.0
Final Conc	0.59	39.0	19.1	55.8	7.7
Final Tail	99.41	0.18	1.36	44.2	92.3
Rougher Feed	106.93	0.51	1.60	132.5	117.3
Conc	1.48	16.2	9.53	58.5	9.7
Tail	105.44	0.29	1.49	73.9	107.6
Scavenger Feed	105.44	0.29	1.49	73.8	107.5
Conc	6.03	2.02	3.69	29.7	15.2
Tail	99.41	0.182	1.36	44.1	92.3
Combined Clnr Feed	1.48	16.2	9.53	58.5	9.7
Final Conc	0.59	39.0	19.1	55.8	7.7
Clnr/Scav Tail	0.89	1.24	3.24	2.7	2.0
Pre-Cleaner Feed	1.56	15.9	9.28	60.6	9.9
Conc	0.55	39.7	19.3	53.1	7.2
Tail	1.01	3.01	3.85	7.4	2.7
Cleaner Feed	1.01	3.01	3.85	7.4	2.7
Conc	0.04	28.3	16.1	2.7	0.4
Tail	0.97	1.99	3.36	4.7	2.2
Clnr/Scav Feed	0.97	1.99	3.36	4.7	2.2
Conc	0.08	10.4	4.63	2.0	0.3
Tail	0.89	1.24	3.24	2.7	2.0
Cleaners Only Feed	1.56	15.9	9.28	45.7	8.5
Final Conc	0.59	39.0	19.1	42.1	6.5
Cleaner Tail	0.97	1.99	3.36	3.6	1.9

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
New Feed	100.0	0.41	1.46	100.0	100.0
Final Conc	0.59	39.0	19.1	55.8	7.7
Final Tail	99.4	0.18	1.36	44.2	92.3
Rougher Feed	100.0	0.51	1.60	100.0	100.0
Conc	1.4	16.2	9.53	44.2	8.2
Tail	98.6	0.29	1.49	55.8	91.8
Scavenger Feed	100.0	0.29	1.49	100.0	100.0
Conc	5.7	2.02	3.69	40.2	14.2
Tail	94.3	0.18	1.36	59.8	85.8
Combined Clnr Feed	100.0	16.2	9.53	100.0	100.0
Final Conc	39.6	39.0	19.1	95.3	79.4
Clnr/Scav Tail	60.4	1.24	3.24	4.7	20.6
Pre-Cleaner Feed	100.0	15.9	9.28	100.0	100.0
Conc	35.1	39.7	19.3	87.7	73.1
Tail	64.9	3.01	3.85	12.3	26.9
Cleaner Feed	100.0	3.01	3.85	100.0	100.0
Conc	3.85	28.3	16.1	36.2	16.1
Tail	96.2	1.99	3.36	63.8	83.9
Clnr/Scav Feed	100.0	1.99	3.36	100.0	100.0
Conc	8.21	10.38	4.63	42.7	11.3
Tail	91.8	1.24	3.24	57.3	88.7
Cleaners Only Feed	100.0	15.9	9.28	100.0	100.0
Final Conc	37.6	39.0	19.1	92.2	77.4
Cleaner Tail	62.4	1.99	3.36	7.8	22.6

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	100.5	12.9	12.9	87.1
6	3,327	123.0	15.8	28.8	71.2
8	2,362	93.2	12.0	40.8	59.2
10	1,651	80.3	10.3	51.1	48.9
14	1,168	64.5	8.3	59.4	40.6
20	833	48.6	6.3	65.7	34.3
28	589	40.5	5.2	70.9	29.1
35	417	33.4	4.3	75.2	24.8
48	295	25.1	3.2	78.4	21.6
65	208	25.1	3.2	81.6	18.4
100	147	23.1	3.0	84.6	15.4
150	104	19.9	2.6	87.2	12.8
200	74	18.1	2.3	89.5	10.5
270	53	15.4	2.0	91.5	8.5
400	37	11.0	1.4	92.9	7.1
Pan	-37	55.1	7.1	100.0	-
Total	-	776.8	100.0	-	-
K80	4,094				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	7.7	2.7	2.7	97.3
14	1,168	28.5	10.0	12.7	87.3
20	833	40.7	14.3	27.0	73.0
28	589	38.7	13.6	40.5	59.5
35	417	31.3	11.0	51.5	48.5
48	295	22.7	8.0	59.5	40.5
65	208	20.3	7.1	66.6	33.4
100	147	17.1	6.0	72.6	27.4
150	104	14.2	5.0	77.6	22.4
200	74	12.4	4.3	81.9	18.1
270	53	10.5	3.7	85.6	14.4
400	37	8.2	2.9	88.5	11.5
Pan	-37	32.9	11.5	100.0	-
Total	-	285.2	100.0	-	-
K80	992				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	17.7	4.2	4.2	95.8
14	1,168	42.9	10.1	14.3	85.7
20	833	62.9	14.9	29.2	70.8
28	589	73.4	17.3	46.5	53.5
35	417	57.7	13.6	60.1	39.9
48	295	35.5	8.4	68.5	31.5
65	208	25.9	6.1	74.7	25.3
100	147	19.5	4.6	79.3	20.7
150	104	15.4	3.6	82.9	17.1
200	74	13.3	3.1	86.0	14.0
270	53	11.2	2.6	88.7	11.3
400	37	8.9	2.1	90.8	9.2
Pan	-37	39.0	9.2	100.0	-
Total	-	**423.3**	**100.0**	-	-
K80	**1,031**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	25.1	6.7	6.7	93.3
14	1,168	64.6	17.2	23.9	76.1
20	833	91.5	24.3	48.2	51.8
28	589	100.3	26.7	74.8	25.2
35	417	52.7	14.0	88.9	11.1
48	295	18.3	4.9	93.7	6.3
65	208	7.3	1.9	95.7	4.3
100	147	3.4	0.9	96.6	3.4
150	104	1.6	0.4	97.0	3.0
200	74	1.2	0.3	97.3	2.7
270	53	1.0	0.3	97.6	2.4
400	37	0.6	0.2	97.7	2.3
Pan	-37	8.5	2.3	100.0	-
Total	-	**376.1**	**100.0**	-	-
K80	**1,277**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	20.9	5.2	5.2	94.8
14	1,168	34.7	8.7	14.0	86.0
20	833	50.7	12.7	26.7	73.3
28	589	65.8	16.5	43.2	56.8
35	417	56.5	14.2	57.4	42.6
48	295	14.3	3.6	61.0	39.0
65	208	27.8	7.0	67.9	32.1
100	147	20.9	5.2	73.2	26.8
150	104	15.9	4.0	77.2	22.8
200	74	13.1	3.3	80.5	19.5
270	53	11.1	2.8	83.2	16.8
400	37	8.8	2.2	85.4	14.6
Pan	-37	58.0	14.6	100.0	-
Total	-	**398.5**	**100.0**	-	-
K80	**999**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	5.8	2.4	2.4	97.6
35	417	32.6	13.8	16.2	83.8
48	295	28.1	11.9	28.1	71.9
65	208	23.4	9.9	37.9	62.1
100	147	26.5	11.2	49.1	50.9
150	104	21.0	8.9	58.0	42.0
200	74	18.7	7.9	65.9	34.1
270	53	15.9	6.7	72.6	27.4
400	37	12.0	5.1	77.7	22.3
Pan	-37	52.9	22.3	100.0	-
Total	-	**236.9**	**100.0**	-	-
K80	**373**				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	2.2	1.4	1.4	98.6
35	417	16.3	10.1	11.5	88.5
48	295	19.1	11.9	23.4	76.6
65	208	19.5	12.1	35.5	64.5
100	147	18.4	11.4	47.0	53.0
150	104	14.6	9.1	56.0	44.0
200	74	12.3	7.6	63.7	36.3
270	53	11.1	6.9	70.6	29.4
400	37	6.9	4.3	74.9	25.1
Pan	-37	40.4	25.1	100.0	-
Total	-	**160.8**	**100.0**	-	-
K80	**326**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	2.0	14.0	14.0	86.0
100	147	0.9	6.3	20.3	79.7
150	104	0.5	3.5	23.8	76.2
200	74	0.4	2.8	26.6	73.4
270	53	0.4	2.8	29.4	70.6
400	37	0.2	1.4	30.8	69.2
Pan	-37	9.9	69.2	100.0	-
Total	-	**14.3**	**100.0**	-	-
K80	**150**				

Test No. PP-20

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	1.1	8.1	8.1	91.9
150	104	0.5	3.7	11.8	88.2
200	74	0.5	3.7	15.4	84.6
270	53	0.6	4.4	19.9	80.1
400	37	0.6	4.4	24.3	75.7
Pan	-37	10.3	75.7	100.0	-
Total	-	**13.6**	**100.0**	-	-
K80	**52.3**				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	5.7	4.8	4.8	95.2
100	147	12.2	10.3	15.1	84.9
150	104	15.7	13.2	28.3	71.7
200	74	16.2	13.6	41.9	58.1
270	53	16.3	13.7	55.6	44.4
400	37	12.2	10.3	65.9	34.1
Pan	-37	40.5	34.1	100.0	-
Total	-	**118.8**	**100.0**	-	-
K80	129				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	4.9	2.6	2.6	97.4
35	417	23.2	12.5	15.1	84.9
48	295	26.1	14.0	29.1	70.9
65	208	23.9	12.8	42.0	58.0
100	147	23.2	12.5	54.5	45.5
150	104	17.7	9.5	64.0	36.0
200	74	13.9	7.5	71.5	28.5
270	53	11.7	6.3	77.7	22.3
400	37	7.9	4.2	82.0	18.0
Pan	-37	33.5	18.0	100.0	-
Total	-	**186.0**	**100.0**	-	-
K80	370				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 316.3 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	2.7	0.0	6.7	5.2	4.2
14	10.0	0.0	17.2	8.7	10.1
20	14.3	0.0	24.3	12.7	14.9
28	13.6	2.4	26.7	16.5	17.3
35	11.0	13.8	14.0	14.2	13.6
48	8.0	11.9	4.9	3.6	8.4
65	7.1	9.9	1.9	7.0	6.1
100	6.0	11.2	0.9	5.2	4.6
150	5.0	8.9	0.4	4.0	3.6
200	4.3	7.9	0.3	3.3	3.1
270	3.7	6.7	0.3	2.8	2.6
400	2.9	5.1	0.2	2.2	2.6
Pan	11.5	22.3	2.3	14.6	8.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	2.7	0.0
14	118 %	9.3	11.0
20	123 %	13.4	16.5
28	109 %	15.1	16.5
35	1679 %	14.0	235.0
48	-306 %	1.5	-4.5
65	55 %	7.1	3.9
100	120 %	5.6	6.7
150	109 %	4.5	4.9
200	119 %	3.8	4.5
270	120 %	3.2	3.8
400	107 %	2.5	2.7
Pan	88 %	17.4	15.3
Total	--	**100.0**	**316.3 %**

Test No. PP-21

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	18.0 % -100 mesh
Rod Mill Feed Grade	0.35 % Cu
Column Conc Grade	48.1 % Cu
Column Copper Rec'y	32.7 %
Flotation Feed Size	51.8 % -100 mesh
Flotation Head Grade	0.24 % Cu
Final Tails Grade	0.10 % Cu
Flotation Copper Grade	37.8 % Cu
Flotation Copper Rec'y	39.4 %
Combined Grade	41.9 % Cu
Combined Recovery	72.1 %

In this test, the circulating load was reduced to about 90%, which was well below the previous run at 300%, but was still above the prior unit column runs at 75%.

This run produced the best overall metallurgical performance of the program, with a combined final concentrate grade of 41.9% Cu at a combined recovery of 72.1%

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	190.0 kg/h -1/4 inch	(Wet Sple 1497.3 g) (Dry Sple 1470.1 g)
Feed Rate:	186.5 kg/h dry ore	(Moisture 1.82 %)
Mill Speed:	45 RPM	(85% of critical speed)
Rod Load:	100 kg	
Rod Mill Feed:	Total	855 kg in 4.50 hr
	Sample	285 kg in 1.50 hr
Rod Mill Discharge:	1,598 g/L	(59 % Sol at SG 2.75)
	60.7 % plus 48 mesh	
	27.1 % minus 100 mesh	
Input Power:	46.82 for 3 disc revolutions	
	0.83 kW (95% drive efficiency)	
Average Power:	0.79 kW Gross	
	0.47 kW No Load	
	0.31 kW Net	
Net Power Usage:	1.69 kWh/t of -1/4 inch feed	
K80 Feed:	4,230 microns	
K80 Product:	1,105 microns	
Work Index (metric):	11.5	

3.1.2. Ball Mill Report:

Feed:	Screen Oversize	(at 87 % circ. load)
Feed Rate:	162.1 kg/h	
Mill Speed:	40 RPM	(77% of critical speed)
Ball Load:	150 kg	
Screen Undersize:	1,147 g/L	(20 % Sol at SG 2.75)
Ball Mill Discharge:	1,693 g/L	(64 % Sol at SG 2.75)
	60.8 % plus 48 mesh	
	29.5 % minus 100 mesh	
Input Power:	33.78 for 3 disc revolutions	
	1.15 kW (95% drive efficiency)	
Average Power:	1.09 kW Gross	
	0.52 kW No Load	
	0.57 kW Net	
Net Power Usage:	3.52 kWh/t of screen oversize	
K80 Feed:	1,105 microns	
K80 Product:	396 microns	
Work Index (metric):	17.5	

3.1.3. Overall Mill Report:

Net Power Usage:	5.21 kWh/t
K80 Feed:	4,230 microns
K80 Product:	396 microns
Work Index (metric):	14.9
Screen Undersize:	51.8 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	4,230	15.3
Rod Mill Discharge	1,105	27.1
Column Feed	~~831~~ 1,200	18.0
Column Conc	71	97.9
Column Tail	1,257	20.0
Ball Mill Feed	1,464	2.4
Ball Mill Discharge	1,178	29.6
Screen Undersize	396	51.8
Rougher Feed	350	55.7
Regrind Feed	~30	95.6
Regrind Discharge	~25	100.0
Final Concentrate	153	79.4
Final Tail	278	58.1

3.2. Reagent Additions:

Average Feed Rate: 0.187 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	12.0	3.86
	DF-250	0.10%	8.0	2.57
	Pine Oil	100%	5.0 dr	14.47
Rougher Feed	PAX	0.10%	7.0	2.25
Scavenger Feed	PAX	0.10%	12.0	3.86
	DF-250	0.10%	2.0	0.64
	Pine Oil	0.10%	2.0	0.64
Scavenger Cell 4	PAX	0.10%	8.0	2.57
	DF-250	0.10%	4.0	1.29
Total	**PAX**			**12.54**
	DF-250			**4.50**
	Pine Oil			**15.12**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,598			2.75
Ball Mill Discharge	1,693			
Screen Feed	1,280			
Screen Undersize	1,147			
Rougher Feed		8.10	15.0	
Pre-Cleaner Feed		8.10		
Cleaner Feed		8.10		
Scavenger Tail	1,107			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	348.7	1,280	13.2	3.0
Rougher	84	213.6	1,147	15.4	5.5
Scavenger	168	212.4	1,127	17.7	9.5
Pre-Cleaner	7.7		measured	1.1	7.0
Cleaner	7.7		measured	1.0	7.7
Clnr/Scav	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow kg/h
	% Cu	% Fe	% Cu	% Fe	
Rod Mill Feed	0.38	1.28	0.35	1.33	186.5
Rod Mill Discharge			0.35	1.33	186.5
Ball Mill Discharge	0.18	0.91	0.12	0.64	162.1
Column Feed	0.24	1.00	0.24	1.01	348.7
Column Conc	47.2	19.5	48.1	19.5	0.45
Column Tail (Scr Fd)	0.18	0.95	0.18	0.99	348.23
Screen Oversize	0.12	0.67	0.12	0.64	162.1
Screen Undersize	0.23	1.43	0.24	1.29	186.1
Rougher Feed	0.32	1.54	0.41	1.50	213.6
Rougher Conc	15.6	9.77	22.5	12.2	1.19
Rougher Tail	0.33	1.52	0.28	1.44	212.4
Scav Tail (final)	0.12	1.42	0.10	1.22	185.4
Scavenger Conc	1.67	2.84	1.53	2.94	27.00
Pre-Cleaner Feed	12.7	8.74	22.1	12.2	1.23
Pre-Cleaner Conc	38.2	19.3	38.1	19.2	0.67
Pre-Cleaner Tail	3.38	4.68	3.18	3.85	0.56
Cleaner Feed	3.10	5.30	3.18	3.85	0.56
Cleaner Conc	29.0	16.7	29.1	16.7	0.02
Cleaner Tail	2.26	4.72	2.20	3.37	0.54
Clnr-Scav Conc	11.2	9.17	11.3	10.1	0.04
Clnr-Scav Tail	1.59	4.59	1.49	2.85	0.50
Flotation Conc	38.5	19.4	37.8	19.1	0.69
Combined Conc			41.9	19.2	1.13

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.00	0.35	1.33	100.0	100.0
Combined Conc	0.61	41.9	19.2	72.1	8.8
Final Tail	99.39	0.10	1.22	27.9	91.2
Column Feed	186.91	0.24	1.01	129.2	142.0
Conc	0.24	48.1	19.5	32.7	3.5
Tail	186.67	0.18	0.99	96.5	138.5
Flotation Feed	99.76	0.24	1.29	67.3	96.5
Conc	0.37	37.8	19.1	39.4	5.3
Tail	99.39	0.10	1.22	27.8	91.3
Rougher Feed	114.50	0.41	1.50	131.4	129.1
Conc	0.64	22.5	12.25	40.6	5.9
Tail	113.86	0.28	1.44	90.8	123.3
Scavenger Feed	113.86	0.28	1.44	90.6	123.3
Conc	14.47	1.53	2.94	62.8	32.0
Tail	99.39	0.099	1.22	27.9	91.3
Combined Clnr Feed	0.64	22.5	12.25	40.6	5.9
Flotation Conc	0.37	37.8	19.1	39.4	5.3
Clnr/Scav Tail	0.27	1.49	2.85	1.2	0.6
Pre-Cleaner Feed	0.66	22.1	12.18	41.3	6.0
Conc	0.36	38.1	19.2	38.6	5.2
Tail	0.30	3.18	3.85	2.6	0.9
Cleaner Feed	0.30	3.18	3.85	2.7	0.9
Conc	0.01	29.1	16.7	0.9	0.1
Tail	0.29	2.20	3.37	1.8	0.7
Clnr/Scav Feed	0.29	2.20	3.37	1.8	0.7
Conc	0.02	11.30	10.09	0.7	0.2
Tail	0.27	1.49	2.85	1.1	0.6

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.35	1.33	100.0	100.0
Combined Conc	0.61	41.9	19.2	72.1	8.8
Final Tail	99.4	0.099	1.22	27.9	91.2
Column Feed	100.0	0.24	1.01	100.0	100.0
Conc	0.13	48.1	19.5	25.3	2.5
Tail	99.9	0.18	0.99	74.7	97.5
Flotation Feed	100.0	0.24	1.29	100.0	100.0
Conc	0.37	37.8	19.1	58.6	5.5
Tail	99.6	0.10	1.22	41.4	94.5
Rougher Feed	100.0	0.41	1.50	100.0	100.0
Conc	0.56	22.5	12.2	30.9	4.5
Tail	99.4	0.28	1.44	69.1	95.5
Scavenger Feed	100.0	0.28	1.44	100.0	100.0
Conc	12.7	1.53	2.94	69.3	25.9
Tail	87.3	0.099	1.22	30.7	74.1
Combined Clnr Feed	100.0	22.5	12.2	100.0	100.0
Flotation Conc	57.8	37.8	19.1	97.1	90.1
Clnr/Scav Tail	42.2	1.49	2.85	2.9	9.9
Pre-Cleaner Feed	100.0	22.1	12.18	100.0	100.0
Conc	54.4	38.1	19.2	93.6	85.7
Tail	45.6	3.18	3.85	6.4	14.3
Cleaner Feed	100.0	3.18	3.85	100.0	100.0
Conc	3.65	29.1	16.7	33.5	15.8
Tail	96.3	2.20	3.37	66.5	84.2
Clnr/Scav Feed	100.0	2.20	3.37	100.0	100.0
Conc	7.24	11.3	10.1	37.1	21.7
Tail	92.8	1.49	2.85	62.9	78.3

5. Screen Analyses: Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	80.7	14.2	14.2	85.8
6	3,327	91.1	16.0	30.1	69.9
8	2,362	71.3	12.5	42.6	57.4
10	1,651	52.4	9.2	51.8	48.2
14	1,168	44.6	7.8	59.7	40.3
20	833	34.5	6.1	65.7	34.3
28	589	29.4	5.2	70.9	29.1
35	417	24.6	4.3	75.2	24.8
48	295	18.5	3.2	78.4	21.6
65	208	18.4	3.2	81.7	18.3
100	147	17.1	3.0	84.7	15.3
150	104	14.4	2.5	87.2	12.8
200	74	12.5	2.2	89.4	10.6
270	53	10.6	1.9	91.2	8.8
400	37	7.1	1.2	92.5	7.5
Pan	-37	42.9	7.5	100.0	-
Total	-	**570.1**	**100.0**	-	-
K80	**4,230**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	11.2	4.8	4.8	95.2
14	1,168	29.9	12.8	17.6	82.4
20	833	31.6	13.5	31.1	68.9
28	589	29.0	12.4	43.5	56.5
35	417	22.9	9.8	53.3	46.7
48	295	17.2	7.4	60.7	39.3
65	208	14.7	6.3	67.0	33.0
100	147	13.9	6.0	72.9	27.1
150	104	10.9	4.7	77.6	22.4
200	74	9.4	4.0	81.6	18.4
270	53	8.0	3.4	85.1	14.9
400	37	6.0	2.6	87.6	12.4
Pan	-37	28.9	12.4	100.0	-
Total	-	**233.6**	**100.0**	-	-
K80	**1,105**				

Test No. PP-21

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	28.8	6.9	6.9	93.1
14	1,168	57.6	13.7	20.6	79.4
20	833	69.0	16.4	37.0	63.0
28	589	68.6	16.4	53.4	46.6
35	417	47.8	11.4	64.8	35.2
48	295	28.8	6.9	71.7	28.3
65	208	23.7	5.6	77.3	22.7
100	147	19.7	4.7	82.0	18.0
150	104	14.3	3.4	85.4	14.6
200	74	10.7	2.6	88.0	12.0
270	53	9.1	2.2	90.1	9.9
400	37	5.9	1.4	91.5	8.5
Pan	-37	35.5	8.5	100.0	-
Total	-	**419.5**	**100.0**	-	-
K80	**1,200**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.8	0.5	0.5	99.5
100	147	2.4	1.6	2.1	97.9
150	104	7.3	4.9	7.0	93.0
200	74	16.2	10.8	17.8	82.2
270	53	25.3	16.9	34.7	65.3
400	37	25.1	16.7	51.4	48.6
Pan	-37	72.9	48.6	100.0	-
Total	-	**150.0**	**100.0**	-	-
K80	**71.0**				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	26.2	8.0	8.0	92.0
14	1,168	49.0	15.0	23.1	76.9
20	833	51.4	15.8	38.9	61.1
28	589	51.6	15.8	54.7	45.3
35	417	34.8	10.7	65.4	34.6
48	295	20.2	6.2	71.6	28.4
65	208	14.2	4.4	75.9	24.1
100	147	13.2	4.1	80.0	20.0
150	104	10.8	3.3	83.3	16.7
200	74	9.1	2.8	86.1	13.9
270	53	8.2	2.5	88.6	11.4
400	37	5.9	1.8	90.4	9.6
Pan	-37	31.2	9.6	100.0	-
Total	-	**325.8**	**100.0**	-	-
K80	**1,257**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	47.7	12.2	12.2	87.8
14	1,168	88.0	22.5	34.8	65.2
20	833	96.0	24.6	59.3	40.7
28	589	95.2	24.4	83.7	16.3
35	417	37.1	9.5	93.2	6.8
48	295	10.8	2.8	96.0	4.0
65	208	4.4	1.1	97.1	2.9
100	147	1.9	0.5	97.6	2.4
150	104	1.1	0.3	97.9	2.1
200	74	1.0	0.3	98.1	1.9
270	53	0.7	0.2	98.3	1.7
400	37	0.6	0.2	98.5	1.5
Pan	-37	6.0	1.5	100.0	-
Total	-	**390.5**	**100.0**	-	-
K80	**1,464**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	22.6	8.3	8.3	91.7
14	1,168	32.3	11.8	20.1	79.9
20	833	35.5	13.0	33.0	67.0
28	589	36.0	13.2	46.2	53.8
35	417	24.8	9.1	55.2	44.8
48	295	15.3	5.6	60.8	39.2
65	208	13.3	4.9	65.7	34.3
100	147	12.9	4.7	70.4	29.6
150	104	11.7	4.3	74.7	25.3
200	74	10.6	3.9	78.6	21.4
270	53	9.4	3.4	82.0	18.0
400	37	6.5	2.4	84.4	15.6
Pan	-37	42.8	15.6	100.0	-
Total	-	273.7	100.0	-	-
K80	1,178				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	4.9	3.7	3.7	96.3
35	417	19.3	14.5	18.2	81.8
48	295	14.8	11.1	29.3	70.7
65	208	11.9	9.0	38.3	61.7
100	147	13.2	9.9	48.2	51.8
150	104	10.7	8.1	56.3	43.7
200	74	9.5	7.1	63.4	36.6
270	53	8.5	6.4	69.8	30.2
400	37	6.7	5.0	74.9	25.1
Pan	-37	33.4	25.1	100.0	-
Total	-	132.9	100.0	-	-
K80	396				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	2.5	3.0	3.0	97.0
35	417	10.2	12.1	15.1	84.9
48	295	8.4	10.0	25.1	74.9
65	208	7.6	9.0	34.1	65.9
100	147	8.6	10.2	44.3	55.7
150	104	7.2	8.6	52.9	47.1
200	74	6.5	7.7	60.6	39.4
270	53	6.1	7.2	67.8	32.2
400	37	4.6	5.5	73.3	26.7
Pan	-37	22.5	26.7	100.0	-
Total	-	**84.2**	**100.0**	-	-
K80	**350**				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	0.2	2.9	2.9	97.1
100	147	0.1	1.5	4.4	95.6
150	104	0.1	1.5	5.9	94.1
200	74	0.1	1.5	7.4	92.6
270	53	0.1	1.5	8.8	91.2
400	37	0.1	1.5	10.3	89.7
Pan	-37	6.1	89.7	100.0	-
Total	-	**6.8**	**100.0**	-	-
K80					

Test No. PP-21

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.0	0.0	0.0	100.0
150	104	0.1	1.5	1.5	98.5
200	74	0.1	1.5	3.1	96.9
270	53	0.1	1.5	4.6	95.4
400	37	0.1	1.5	6.2	93.8
Pan	-37	6.1	93.8	100.0	-
Total	-	**6.5**	**100.0**	-	-
K80					

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	14.8	5.2	5.2	94.8
100	147	44.2	15.4	20.6	79.4
150	104	65.3	22.8	43.4	56.6
200	74	58.7	20.5	63.9	36.1
270	53	42.1	14.7	78.7	21.3
400	37	22.8	8.0	86.6	13.4
Pan	-37	38.3	13.4	100.0	-
Total	-	**286.2**	**100.0**	-	-
K80	**153**				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.8	0.7	0.7	99.3
35	417	7.4	6.6	7.3	92.7
48	295	12.3	11.0	18.3	81.7
65	208	11.7	10.5	28.8	71.2
100	147	14.7	13.1	41.9	58.1
150	104	11.1	9.9	51.9	48.1
200	74	9.2	8.2	60.1	39.9
270	53	8.2	7.3	67.4	32.6
400	37	5.9	5.3	72.7	27.3
Pan	-37	30.5	27.3	100.0	-
Total	-	**111.8**	**100.0**	-	-
K80	**278**				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 85.3 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	4.8	0.0	12.2	8.3	6.9
14	12.8	0.0	22.5	11.8	13.7
20	13.5	0.0	24.6	13.0	16.4
28	12.4	3.7	24.4	13.2	16.4
35	9.8	14.5	9.5	9.1	11.4
48	7.4	11.1	2.8	5.6	6.9
65	6.3	9.0	1.1	4.9	5.6
100	6.0	9.9	0.5	4.7	4.7
150	4.7	8.1	0.3	4.3	3.4
200	4.0	7.1	0.3	3.9	2.6
270	3.4	6.4	0.2	3.4	2.2
400	2.6	5.0	0.2	2.4	2.2
Pan	12.4	25.1	1.5	15.6	7.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR	
10	0 %	4.8	0.0	
14	119 %	12.3	14.6	
20	116 %	13.2	15.4	
28	78 %	12.7	9.9	
35	-1073 %	9.0	-96.4	disregard
48	134 %	6.3	8.5	
65	71 %	5.7	4.1	
100	94 %	5.4	5.0	
150	85 %	4.5	3.8	
200	86 %	4.0	3.4	
270	91 %	3.4	3.1	
400	111 %	2.5	2.7	
Pan	90 %	16.3	14.7	
Total	--	**100.0**	**85.3 %**	

1. **Purpose:** To operate with very high circulating loads in the grinding circuit.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	7.6 % -100 mesh
Rod Mill Feed Grade	0.44 % Cu
Column Conc Grade	42.1 % Cu
Column Copper Rec'y	28.4 %
Flotation Feed Size	46.8 % -100 mesh
Flotation Head Grade	0.32 % Cu
Final Tails Grade	0.26 % Cu
Flotation Copper Grade	41.5 % Cu
Flotation Copper Rec'y	14.0 %
Combined Grade	41.9 % Cu
Combined Recovery	42.4 %

The circuit was operated at a circulating load of +500%, and resulted in a mass feed rate to the column of 1,200 kg/h. The column was originally designed to treat up to 200 kg/h, and operation at the very high feed rate probably represents the upper limit for this unit.

Metallurgical performance in the unit column was adequate, but the conventional circuit performed poorly, and the overall results were accordingly poor.

Althought the grade was good at 41.9% Cu, the recovery, at 42.4%, was very poor.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	198.5 kg/h	-1/4 inch	(Wet Sple 594.1 g)
			(Dry Sple 584.0 g)
Feed Rate:	195.1 kg/h	dry ore	(Moisture 1.70 %)
Mill Speed:	45 RPM	(85% of critical speed)	
Rod Load:	100 kg		
Rod Mill Feed:	Total	828 kg in 4.17 hr	
	Sample	99 kg in 0.50 hr	
Rod Mill Discharge:	1,605 g/L	(59 % Sol at SG 2.75)	
	59.0	% plus 48 mesh	
	27.9	% minus 100 mesh	
Input Power:**	42.33	for 3 disc revolutions	
	0.92	kW (95% drive efficiency)	
Average Power:	0.87 kW	Gross	
	0.47 kW	No Load	
	0.40 kW	Net	
Net Power Usage:	2.04 kWh/t	of -1/4 inch feed	
K80 Feed:	3,707	microns	
K80 Product:	984	microns	
Work Index (metric):	13.2		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 526 % circ. load)
Feed Rate:	1,026.8 kg/h		
Mill Speed:	40 RPM	(77% of critical speed)	
Ball Load:	150 kg		
Screen Undersize:	1,110 g/L	(16 % Sol at SG 2.75)	
Ball Mill Discharge:	1,693 g/L	(64 % Sol at SG 2.75)	
	90.7	% plus 48 mesh	
	6.0	% minus 100 mesh	
Input Power:	31.00	for 3 disc revolutions	
	1.25	kW (95% drive efficiency)	
Average Power:	1.19 kW	Gross	
	0.52 kW	No Load	
	0.67 kW	Net	
Net Power Usage:	0.65 kWh/t	of screen oversize	
K80 Feed:	984	microns	
K80 Product:	448	microns	
Work Index (metric):	4.2		

3.1.3. Overall Mill Report:

Net Power Usage:	2.69 kWh/t
K80 Feed:	3,707 microns
K80 Product:	448 microns
Work Index (metric):	8.7
Screen Undersize:	46.8 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	3,707	16.3
Rod Mill Discharge	984	27.9
Column Feed		
Column Conc	70	95.4
Column Tail	1,338	11.4
Ball Mill Feed	1,439	2.5
Ball Mill Discharge	1,400	6.0
Screen Undersize	448	46.8
Rougher Feed	316	59.6
Regrind Feed	35	98.5
Regrind Discharge	30	100.0
Final Concentrate	119	88.3
Final Tail	469	37.9

3.2. Reagent Additions:

Average Feed Rate: 0.195 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	11.8	3.63
	DF-250	0.10%	7.9	2.43
	Pine Oil	100%	4.5 dr	12.45
Rougher Feed	PAX	0.10%	7.0	2.15
Scavenger Feed	PAX	0.10%	12.0	3.69
	DF-250	0.10%	2.0	0.61
	Pine Oil	0.10%	2.0	0.61
Scavenger Cell 4	PAX	0.10%	8.1	2.49
	DF-250	0.10%	3.8	1.17
Total	**PAX**			**11.96**
	DF-250			**4.21**
	Pine Oil			**13.07**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,605			2.75
Ball Mill Discharge				
Screen Feed	1,555			
Screen Undersize	1,110			
Rougher Feed		8.00	15.0	
Pre-Cleaner Feed		8.00		
Cleaner Feed		8.00		
Scavenger Tail	1,140			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	1,221.9	1,555	23.4	1.7
Rougher	84	204.0	1,110	19.7	4.3
Scavenger	168	203.5	1,125	17.3	9.7
Pre-Cleaner*	7.7		measured	1.1	7.0
Cleaner*	7.7		measured	1.0	7.7
Clnr/Scav*	7.7		measured	0.9	8.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Product	Direct Assays		Adjusted Assays		Mass Flow
	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.38	1.45	0.45	1.56	195.1
Rod Mill Discharge			0.45	1.56	195.1
Ball Mill Discharge	0.12	0.78	0.12	0.81	1,026.8
Column Feed			0.17	0.93	1,221.9
Column Conc	45.0	18.7	42.1	18.6	0.59
Column Tail (Scr Fd)	0.17	0.98	0.15	0.92	1,221.3
Screen Oversize	0.11	0.78	0.12	0.81	1,026.8
Screen Undersize	0.38	1.64	0.32	1.51	194.5
Rougher Feed	0.52	1.98	0.48	1.63	204.0
Rougher Conc	24.7	12.7	24.9	13.2	0.49
Rougher Tail	0.42	1.75	0.43	1.60	203.5
Scav Tail (final)	0.26	1.41	0.26	1.48	194.2
Scavenger Conc	3.84	4.02	3.92	4.15	9.28
Pre-Cleaner Feed	2.41	12.8	24.4	13.1	0.51
Pre-Cleaner Conc	41.7	20.0	41.9	20.1	0.28
Pre-Cleaner Tail	2.51	4.10	2.86	4.44	0.23
Cleaner Feed	2.68	4.75	2.86	4.44	0.23
Cleaner Conc	32.4	17.4	32.2	17.8	0.01
Cleaner Tail	1.14	3.21	1.37	3.76	0.22
Clnr-Scav Conc	10.5	8.92	9.50	9.14	0.02
Clnr-Scav Tail	0.92	3.81	0.71	3.32	0.20
Flotation Conc	41.5	20.1	41.5	20.0	0.29
Combined Conc			41.9	19.1	0.88

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.00	0.45	1.56	100.0	100.0
Combined Conc	0.45	41.9	19.1	42.4	5.5
Final Tail	99.55	0.258	1.48	57.6	94.5
Column Feed	626.21	0.17	0.93	242.0	373.5
Conc	0.30	42.1	18.6	28.4	3.6
Tail	625.91	0.15	0.92	213.7	369.9
Flotation Feed	99.70	0.32	1.51	71.7	96.4
Conc	0.15	41.5	20.0	14.0	1.9
Tail	99.55	0.26	1.48	57.7	94.5
Rougher Feed	104.56	0.48	1.63	113.7	109.2
Conc	0.25	24.9	13.21	14.1	2.1
Tail	104.30	0.43	1.60	99.6	107.1
Scavenger Feed	104.30	0.43	1.60	99.6	107.1
Conc	4.75	3.92	4.15	41.9	12.6
Tail	99.55	0.258	1.48	57.7	94.5
Combined Clnr Feed	0.25	24.9	13.21	14.1	2.1
Flotation Conc	0.15	41.5	20.0	14.0	1.9
Clnr/Scav Tail	0.10	0.71	3.32	0.2	0.2
Pre-Cleaner Feed	0.26	24.4	13.08	14.3	2.2
Conc	0.14	41.9	20.1	13.5	1.9
Tail	0.12	2.86	4.44	0.8	0.3
Cleaner Feed	0.12	2.86	4.44	0.8	0.3
Conc	0.01	32.2	17.8	0.4	0.1
Tail	0.11	1.37	3.76	0.3	0.3
Clnr/Scav Feed	0.11	1.37	3.76	0.3	0.3
Conc	0.01	9.50	9.14	0.2	0.0
Tail	0.10	0.71	3.32	0.2	0.2

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.45	1.56	100.0	100.0
Combined Conc	0.45	41.9	19.1	42.4	5.5
Final Tail	99.6	0.258	1.48	57.6	94.5
Column Feed	100.0	0.17	0.93	100.0	100.0
Conc	0.05	42.1	18.6	11.7	1.0
Tail	100.0	0.15	0.92	88.3	99.0
Flotation Feed	100.0	0.32	1.51	100.0	100.0
Conc	0.15	41.5	20.0	19.5	2.0
Tail	99.8	0.26	1.48	80.5	98.0
Rougher Feed	100.0	0.48	1.63	100.0	100.0
Conc	0.24	24.9	13.2	12.4	2.0
Tail	99.8	0.43	1.60	87.6	98.0
Scavenger Feed	100.0	0.43	1.60	100.0	100.0
Conc	4.6	3.92	4.15	42.1	11.8
Tail	95.4	0.258	1.48	57.9	88.2
Combined Clnr Feed	100.0	24.9	13.2	100.0	100.0
Flotation Conc	59.3	41.5	20.0	98.9	89.8
Clnr/Scav Tail	40.7	0.71	3.32	1.1	10.2
Pre-Cleaner Feed	100.0	24.4	13.08	100.0	100.0
Conc	55.2	41.9	20.1	94.7	84.7
Tail	44.8	2.86	4.44	5.3	15.3
Cleaner Feed	100.0	2.86	4.44	100.0	100.0
Conc	5.13	32.2	17.8	57.6	20.5
Tail	94.9	1.37	3.76	42.4	79.5
Clnr/Scav Feed	100.0	1.37	3.76	100.0	100.0
Conc	7.21	9.5	9.1	49.9	17.5
Tail	92.8	0.71	3.32	50.1	82.5

5. Screen Analyses:

Detailed in the following pages.

Test No. PP-22

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	30.5	9.8	9.8	90.2
6	3,327	46.0	14.7	24.5	75.5
8	2,362	35.8	11.5	35.9	64.1
10	1,651	35.8	11.5	47.4	52.6
14	1,168	28.3	9.1	56.5	43.5
20	833	20.8	6.7	63.1	36.9
28	589	18.3	5.9	69.0	31.0
35	417	14.7	4.7	73.7	26.3
48	295	11.6	3.7	77.4	22.6
65	208	9.8	3.1	80.5	19.5
100	147	9.9	3.2	83.7	16.3
150	104	8.3	2.7	86.4	13.6
200	74	7.9	2.5	88.9	11.1
270	53	6.9	2.2	91.1	8.9
400	37	5.1	1.6	92.7	7.3
Pan	-37	22.7	7.3	100.0	-
Total	-	312.4	100.0	-	-
K80	3,707				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.2	1.8	1.8	98.2
14	1,168	22.7	9.7	11.4	88.6
20	833	36.7	15.6	27.1	72.9
28	589	31.9	13.6	40.6	59.4
35	417	25.2	10.7	51.4	48.6
48	295	17.9	7.6	59.0	41.0
65	208	16.0	6.8	65.8	34.2
100	147	14.8	6.3	72.1	27.9
150	104	11.8	5.0	77.1	22.9
200	74	9.9	4.2	81.3	18.7
270	53	9.0	3.8	85.1	14.9
400	37	6.3	2.7	87.8	12.2
Pan	-37	28.6	12.2	100.0	-
Total	-	235.0	100.0	-	-
K80	984				

Test No. PP-22

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	6.0	3.3	3.3	96.7
100	147	2.2	1.2	4.6	95.4
150	104	7.0	3.9	8.5	91.5
200	74	16.0	8.9	17.4	82.6
270	53	28.4	15.8	33.3	66.7
400	37	29.4	16.4	49.7	50.3
Pan	-37	90.2	50.3	100.0	-
Total	-	**179.2**	**100.0**	-	-
K80	**70.1**				

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	31.6	9.4	9.4	90.6
14	1,168	57.5	17.0	26.4	73.6
20	833	71.9	21.3	47.7	52.3
28	589	69.5	20.6	68.3	31.7
35	417	33.7	10.0	78.3	21.7
48	295	15.2	4.5	82.8	17.2
65	208	10.0	3.0	85.8	14.2
100	147	9.4	2.8	88.6	11.4
150	104	6.4	1.9	90.5	9.5
200	74	4.9	1.5	91.9	8.1
270	53	4.3	1.3	93.2	6.8
400	37	2.7	0.8	94.0	6.0
Pan	-37	20.2	6.0	100.0	-
Total	-	**337.3**	**100.0**	-	-
K80	**1,338**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	50.5	11.6	11.6	88.4
14	1,168	92.2	21.2	32.8	67.2
20	833	111.0	25.5	58.4	41.6
28	589	111.9	25.8	84.1	15.9
35	417	40.6	9.3	93.5	6.5
48	295	11.4	2.6	96.1	3.9
65	208	4.2	1.0	97.1	2.9
100	147	1.8	0.4	97.5	2.5
150	104	1.0	0.2	97.7	2.3
200	74	0.8	0.2	97.9	2.1
270	53	0.7	0.2	98.1	1.9
400	37	0.3	0.1	98.1	1.9
Pan	-37	8.1	1.9	100.0	-
Total	-	**434.5**	**100.0**	-	-
K80	**1,439**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	23.8	10.8	10.8	89.2
14	1,168	42.0	19.1	29.9	70.1
20	833	51.9	23.6	53.5	46.5
28	589	51.4	23.4	76.9	23.1
35	417	22.2	10.1	87.0	13.0
48	295	8.2	3.7	90.7	9.3
65	208	4.4	2.0	92.7	7.3
100	147	2.8	1.3	94.0	6.0
150	104	1.8	0.8	94.8	5.2
200	74	1.4	0.6	95.4	4.6
270	53	1.2	0.5	96.0	4.0
400	37	0.7	0.3	96.3	3.7
Pan	-37	8.2	3.7	100.0	-
Total	-	**220.0**	**100.0**	-	-
K80	**1,400**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	4.1	4.3	4.3	95.7
35	417	17.4	18.3	22.6	77.4
48	295	11.1	11.7	34.2	65.8
65	208	8.1	8.5	42.8	57.2
100	147	9.9	10.4	53.2	46.8
150	104	7.6	8.0	61.1	38.9
200	74	6.4	6.7	67.9	32.1
270	53	5.4	5.7	73.5	26.5
400	37	3.9	4.1	77.6	22.4
Pan	-37	21.3	22.4	100.0	-
Total	-	**95.2**	**100.0**	-	-
K80	**448**				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.4	2.3	2.3	97.7
35	417	6.6	10.6	12.9	87.1
48	295	5.6	9.0	21.9	78.1
65	208	5.6	9.0	30.9	69.1
100	147	5.9	9.5	40.4	59.6
150	104	4.9	7.9	48.2	51.8
200	74	4.8	7.7	55.9	44.1
270	53	4.3	6.9	62.9	37.1
400	37	3.4	5.5	68.3	31.7
Pan	-37	19.7	31.7	100.0	-
Total	-	**62.2**	**100.0**	-	-
K80	**316**				

Test No. PP-22

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	0.0	0.0	0.0	100.0
100	147	0.1	1.5	1.5	98.5
150	104	0.1	1.5	3.0	97.0
200	74	0.4	6.0	9.0	91.0
270	53	0.3	4.5	13.4	86.6
400	37	0.4	6.0	19.4	80.6
Pan	-37	5.4	80.6	100.0	-
Total	-	6.7	100.0	-	-
K80	36				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.0	0.0	0.0	100.0
150	104	0.2	3.4	3.4	96.6
200	74	0.2	3.4	6.8	93.2
270	53	0.4	6.8	13.6	86.4
400	37	0.3	5.1	18.6	81.4
Pan	-37	4.8	81.4	100.0	-
Total	-	5.9	100.0	-	-
K80	35.0				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.9	3.2	3.2	96.8
100	147	7.6	8.4	11.7	88.3
150	104	12.0	13.3	25.0	75.0
200	74	13.4	14.9	39.8	60.2
270	53	12.3	13.7	53.5	46.5
400	37	9.0	10.0	63.5	36.5
Pan	-37	32.9	36.5	100.0	-
Total	-	90.1	100.0	-	-
K80	119				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	5.3	5.8	5.8	94.2
35	417	17.3	18.9	24.7	75.3
48	295	16.5	18.0	42.7	57.3
65	208	9.2	10.1	52.8	47.2
100	147	8.5	9.3	62.1	37.9
150	104	5.8	6.3	68.4	31.6
200	74	4.6	5.0	73.4	26.6
270	53	4.1	4.5	77.9	22.1
400	37	2.8	3.1	81.0	19.0
Pan	-37	17.4	19.0	100.0	-
Total	-	91.5	100.0	-	-
K80	469				

Test No. PP-22

Calculation of Circulating Load Ratio (CLR)

LR-3897

Weighted Average CLR 565.8 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	1.8	0.0	11.6	10.8	0.0
14	9.7	0.0	21.2	19.1	0.0
20	15.6	0.0	25.5	23.6	0.0
28	13.6	4.3	25.8	23.4	0.0
35	10.7	18.3	9.3	10.1	0.0
48	7.6	11.7	2.6	3.7	0.0
65	6.8	8.5	1.0	2.0	3.3
100	6.3	10.4	0.4	1.3	1.2
150	5.0	8.0	0.2	0.8	3.9
200	4.2	6.7	0.2	0.6	8.9
270	3.8	5.7	0.2	0.5	15.8
400	2.7	4.1	0.1	0.3	0.0
Pan	12.2	22.4	1.9	3.7	66.7
Total	100.0	100.0	100.0	100.0	100.0

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	1.8	0.0
14	454 %	17.4	78.9
20	799 %	22.7	181.3
28	388 %	21.4	82.8
35	1011 %	10.1	102.6
48	366 %	4.6	16.7
65	164 %	3.8	6.3
100	478 %	2.1	10.2
150	504 %	1.5	7.6
200	555 %	1.2	6.6
270	479 %	1.1	5.3
400	568 %	0.7	3.8
Pan	548 %	11.6	63.6
Total	--	100.0	565.8 %

Test No. PP-22 LR-3897

Unit Column Concentrate 0.585 kg/h

Particle Size		Solids			Copper			Iron		
		Weight	% Ret.	% Ret	Assay %Cu		% Ret	Assay %Fe		% Ret
µm	Mesh	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
208	65	6.0	3.3	3.3	7.24	7.24	0.5	23.5	23.5	4.0
147	100	2.2	1.2	4.6	40.1	16.1	1.6	20.3	22.6	5.3
104	150	7.0	3.9	8.5	46.6	30.1	5.6	19.4	21.1	9.1
74	200	16.0	8.9	17.4	46.8	38.7	14.8	19.0	20.0	17.8
53	270	28.4	15.8	33.3	47.7	43.0	31.3	19.8	19.9	33.8
37	400	29.4	16.4	49.7	47.5	44.5	48.4	20.6	20.2	51.0
-37	Pan	90.2	50.3	100.0	46.7	45.6	100.0	19.1	19.6	100.0
Total		**179.2**	**100.0**	--	**45.6**	--	--	**19.6**	--	--
Direct					**45.0**			**18.7**		

Unit Column Tail (Screen Feed) 1221.3 kg/h

Particle Size		Solids			Copper			Iron		
		Weight	% Ret.	% Ret	Assay %Cu		% Ret	Assay %Fe		% Ret
µm	Mesh	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
1,651	10	31.6	9.4	9.4	0.09	0.09	3.1	0.74	0.74	6.9
1,168	14	57.5	17.0	26.4	0.13	0.12	11.3	0.66	0.69	18.1
833	20	71.9	21.3	47.7	0.12	0.12	20.7	0.65	0.67	31.9
589	28	69.5	20.6	68.3	0.14	0.12	31.4	0.71	0.68	46.4
417	35	33.7	10.0	78.3	0.22	0.14	39.5	1.06	0.73	56.9
295	48	15.2	4.5	82.8	0.37	0.15	45.6	1.17	0.75	62.2
208	65	10.0	3.0	85.8	0.54	0.16	51.5	1.50	0.78	66.6
147	100	9.4	2.8	88.6	0.64	0.18	58.1	1.73	0.81	71.4
104	150	6.4	1.9	90.5	0.71	0.19	63.1	1.94	0.83	75.0
74	200	4.9	1.5	91.9	0.89	0.20	67.9	2.25	0.86	78.3
53	270	4.3	1.3	93.2	1.25	0.21	73.7	2.43	0.88	81.4
37	400	2.7	0.8	94.0	1.71	0.23	78.8	2.62	0.89	83.4
-37	Pan	20.2	6.0	100.0	0.96	0.27	100.0	2.78	1.01	100.0
Total		**337.3**	**100.0**	--	**0.27**	--	--	**1.01**	--	--
Direct					**0.17**			**0.98**		

Screen Undersize (Flotation Feed) 194.54 kg/h

Particle Size		Solids			Copper			Iron		
		Weight	% Ret.	% Ret	Assay %Cu		% Ret	Assay %Fe		% Ret
µm	Mesh	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
589	28	4.1	4.3	4.3	0.14	0.14	1.2	1.07	1.07	2.6
417	35	17.4	18.3	22.6	0.25	0.23	10.3	0.97	0.99	12.6
295	48	11.1	11.7	34.2	0.34	0.27	18.3	1.39	1.13	21.7
208	65	8.1	8.5	42.8	0.45	0.30	25.9	1.50	1.20	28.9
147	100	9.9	10.4	53.2	0.57	1.28	37.8	1.66	4.66	38.6
104	150	7.6	8.0	61.1	0.61	1.05	47.5	1.86	3.68	47.0
74	200	6.4	6.7	67.9	0.57	0.94	55.2	1.94	3.28	54.3
53	270	5.4	5.7	73.5	0.77	0.91	63.9	2.19	3.10	61.3
37	400	3.9	4.1	77.6	0.74	0.89	70.0	2.15	3.00	66.2
-37	Pan	21.3	22.4	100.0	0.67	0.81	100.0	2.68	2.89	100.0
Total		**95.2**	**100.0**	--	**0.50**	--	--	**1.78**	--	--
Direct					**0.38**			**1.64**		

Mechanical Concentrate 0.293 kg/h

Particle Size		Solids			Copper			Iron		
		Weight	% Ret.	% Ret	Assay %Cu		% Ret	Assay %Fe		% Ret
µm	Mesh	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
208	65	2.9	3.2	3.2	36.5	36.5	2.9	23.5	23.5	3.9
147	100	7.6	8.4	11.7	42.1	40.6	11.7	20.3	21.2	12.6
104	150	12.0	13.3	25.0	42.4	41.5	25.7	19.4	20.2	25.8
74	200	13.4	14.9	39.8	42.4	41.9	41.3	19.0	19.8	40.2
53	270	12.3	13.7	53.5	43.0	42.2	55.8	19.8	19.8	53.9
37	400	9.0	10.0	63.5	42.9	42.3	66.4	20.6	19.9	64.4
-37	Pan	32.9	36.5	100.0	37.2	40.4	100.0	19.1	19.6	100.0
Total		**90.1**	**100.0**	--	**40.4**	--	--	**19.6**	--	--
Direct					**41.5**			**20.1**		

Test No. PP-22

LR-3897

Final Tails

194.25 kg/h

Particle Size		Solids			Copper			Iron		
		Weight	% Ret.	% Ret	Assay %Cu		% Ret	Assay %Fe		% Ret
µm	Mesh	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
589	28	5.3	5.8	5.8	0.25	0.25	4.9	0.99	0.99	3.4
417	35	17.3	18.9	24.7	0.20	0.21	17.7	0.89	0.91	13.5
295	48	16.5	18.0	42.7	0.37	0.28	40.2	1.28	1.07	27.4
208	65	9.2	10.1	52.8	0.58	0.34	60.0	1.67	1.18	37.4
147	100	8.5	9.3	62.1	0.48	1.47	75.0	1.76	5.22	47.2
104	150	5.8	6.3	68.4	0.25	1.11	80.4	1.82	4.22	54.1
74	200	4.6	5.0	73.4	0.11	0.92	82.3	1.92	3.78	59.9
53	270	4.1	4.5	77.9	0.042	0.79	82.9	1.91	3.51	65.0
37	400	2.8	3.1	81.0	0.037	0.72	83.3	2.10	3.38	68.9
-37	Pan	17.4	19.0	100.0	0.26	0.56	100.0	2.73	3.15	100.0
Total		**91.5**	**100.0**	--	**0.30**	--	--	**1.67**	--	--
Direct					**0.26**			**1.41**		

Unit Column Concentrate 0.585 kg/h

Particle Size		Solids			Copper			Iron		
		% Ret.	Rate	% Ret	Assay	Distribution		Assay	Distribution	
µm	Mesh	Indiv.	kg/h	Cuml.	%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
208	65	3.3	0.020	3.3	7.24	0.53	0.5	23.5	4.0	4.0
147	100	1.2	0.007	4.6	40.1	1.08	1.6	20.3	1.3	5.3
104	150	3.9	0.023	8.5	46.6	3.99	5.6	19.4	3.9	9.1
74	200	8.9	0.052	17.4	46.8	9.17	14.8	19.0	8.6	17.8
53	270	15.8	0.093	33.3	47.7	16.6	31.3	19.8	16.0	33.8
37	400	16.4	0.096	49.7	47.5	17.1	48.4	20.6	17.2	51.0
-37	Pan	50.3	0.295	100.0	46.7	51.6	100.0	19.1	49.0	100.0
Total		**100.0**	**0.585**	--	**45.6**	--	--	**19.6**	--	--
Direct					**45.0**			**18.7**		

Unit Column Tail (Screen Feed) 1221.3 kg/h

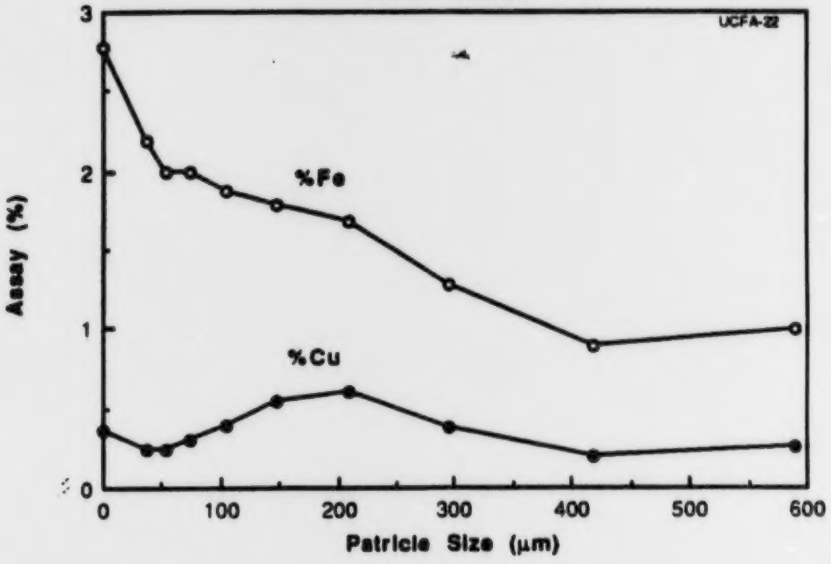
Particle Size		Solids			Copper			Iron		
		% Ret.	Rate	% Ret	Assay	Distribution		Assay	Distribution	
µm	Mesh	Indiv.	kg/h	Cuml.	%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
1,651	10	9.4	114.4	9.4	0.09	3.11	3.1	0.74	6.89	6.9
1,168	14	17.0	208.2	26.4	0.13	8.18	11.3	0.66	11.2	18.1
833	20	21.3	260.3	47.7	0.12	9.44	20.7	0.65	13.8	31.9
589	28	20.6	251.6	68.3	0.14	10.6	31.4	0.71	14.5	46.4
417	35	10.0	122.0	78.3	0.22	8.11	39.5	1.06	10.5	56.9
295	48	4.5	55.0	82.8	0.37	6.15	45.6	1.17	5.24	62.2
208	65	3.0	36.2	85.8	0.54	5.91	51.5	1.50	4.42	66.6
147	100	2.8	34.0	88.6	0.64	6.58	58.1	1.73	4.79	71.4
104	150	1.9	23.2	90.5	0.71	4.97	63.1	1.94	3.66	75.0
74	200	1.5	17.7	91.9	0.89	4.77	67.9	2.25	3.25	78.3
53	270	1.3	15.6	93.2	1.25	5.88	73.7	2.43	3.08	81.4
37	400	0.8	9.8	94.0	1.71	5.05	78.8	2.62	2.08	83.4
-37	Pan	6.0	73.1	100.0	0.96	21.2	100.0	2.78	16.6	100.0
Total		**100.0**	**1,221**	--	**0.27**	--	--	**1.01**	--	--
Direct					**0.17**			**0.98**		

Unit Column Feed (calc) **1221.9 kg/h**

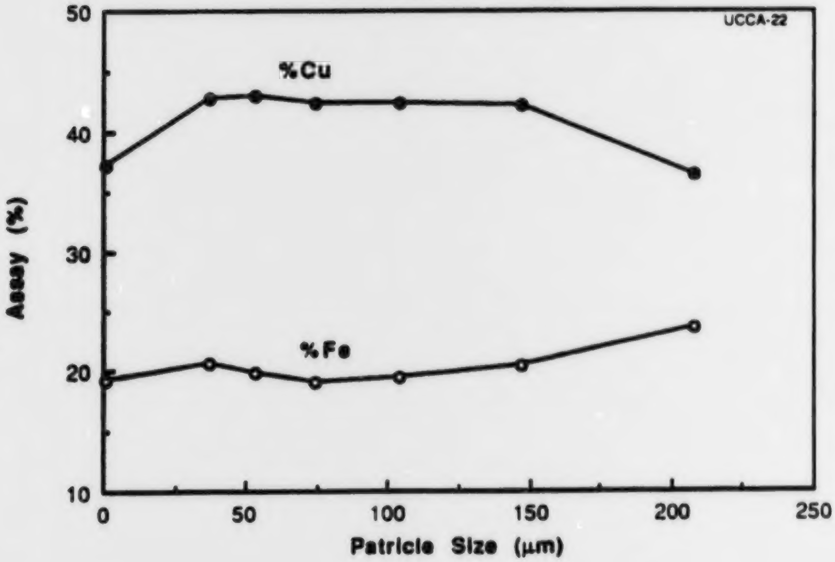
Particle Size		Solids			Copper			Iron		
		% Ret.	Rate	% Ret	Assay	Distribution		Assay	Distribution	
µm	Mesh	Indiv.	kg/h	Cuml.	%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
1,651	10	9.4	114.4	9.4	0.09	2.9	2.9	0.74	6.8	6.8
1,168	14	17.0	208.2	26.4	0.13	7.6	10.4	0.66	11.1	17.9
833	20	21.3	260.3	47.7	0.12	8.7	19.2	0.65	13.6	31.6
589	28	20.6	251.6	68.3	0.14	9.8	29.0	0.71	14.4	46.0
417	35	10.0	122.0	78.3	0.22	7.5	36.5	1.06	10.4	56.4
295	48	4.5	55.0	82.8	0.37	5.7	42.2	1.17	5.2	61.6
208	65	3.0	36.2	85.8	0.54	5.5	47.7	1.51	4.4	66.0
147	100	2.8	34.0	88.5	0.65	6.2	53.9	1.73	4.8	70.8
104	150	1.9	23.2	90.4	0.76	4.9	58.8	1.96	3.7	74.4
74	200	1.5	17.8	91.9	1.02	5.1	63.9	2.30	3.3	77.7
53	270	1.3	15.7	93.2	1.53	6.7	70.6	2.53	3.2	80.9
37	400	0.8	9.9	94.0	2.16	5.9	76.5	2.79	2.2	83.1
-37	Pan	6.0	73.4	100.0	1.14	23.5	100.0	2.85	16.9	100.0
Total		**100.0**	**1,222**	--	**0.29**	--	--	**1.01**	--	--
Direct					**0.17**			**0.98**		

Recovery to Concentrate

Particle Size		Recovery to Concentrate		
µm	Mesh	Sol	Cu	Fe
208	65	0.05	0.72	0.84
147	100	0.02	1.31	0.25
104	150	0.10	6.08	0.98
74	200	0.29	13.4	2.43
53	270	0.59	18.5	4.63
37	400	0.97	21.4	7.17
-37	Pan	0.40	16.4	2.69

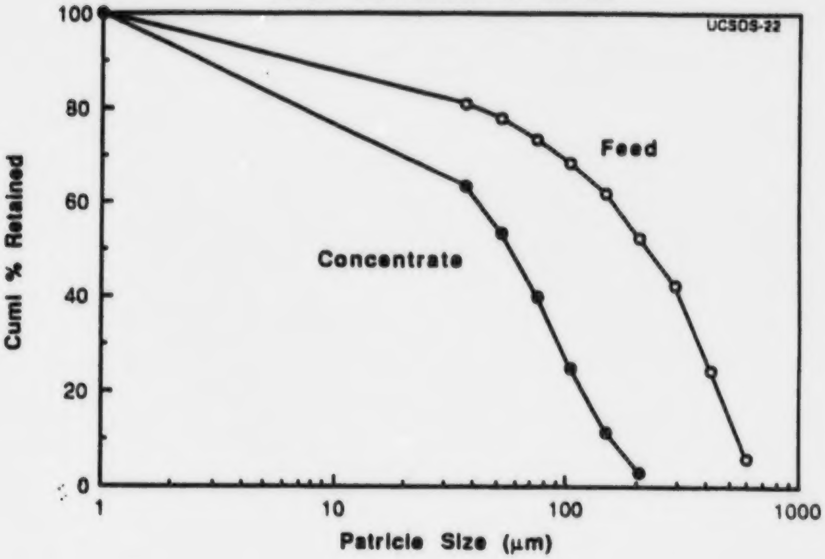


Unit Column
Feed Assays

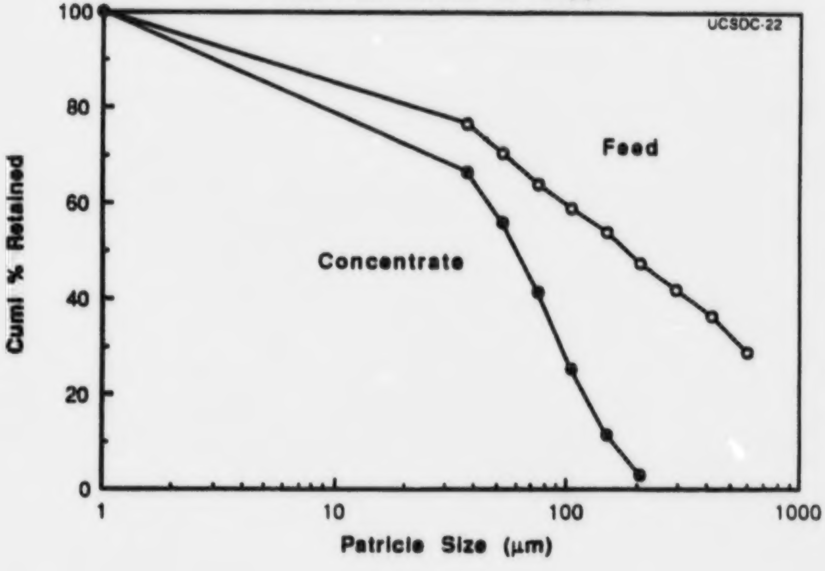


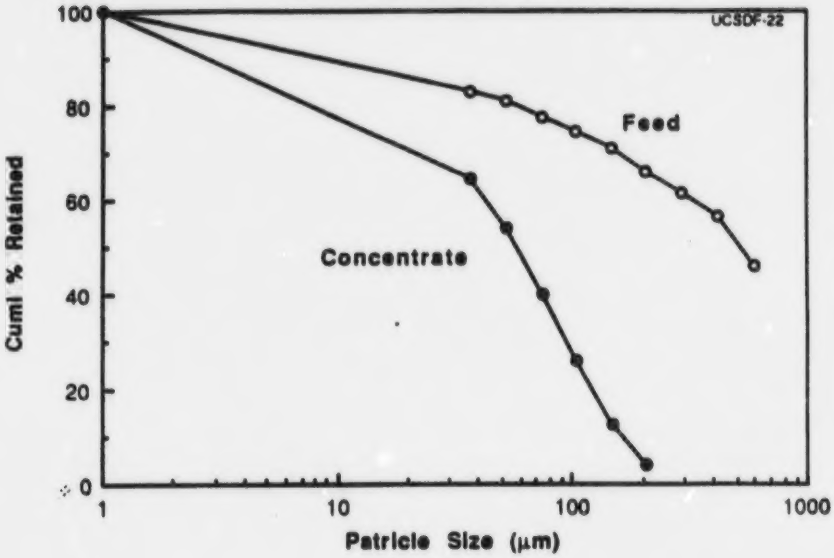
Unit Column
Concentrate Assays

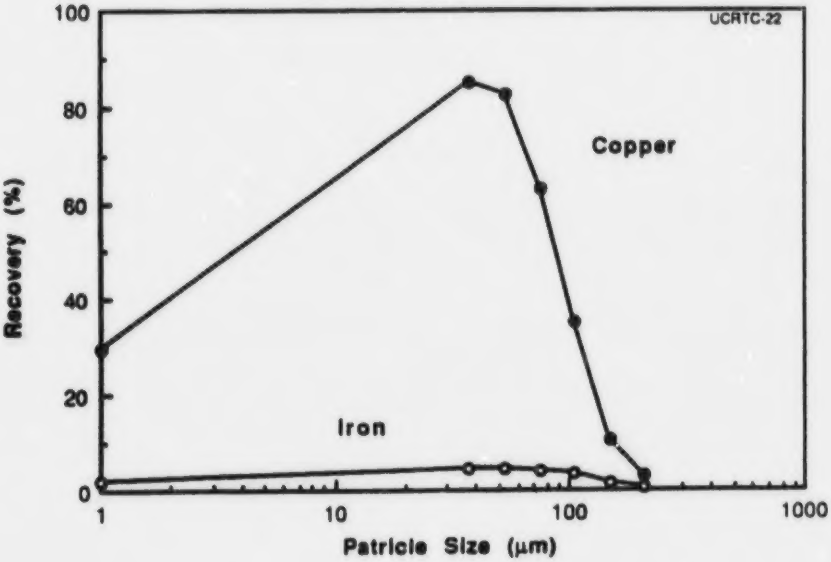
Unit Column
Size Distribution of Solids



Unit Column
Size Distribution of Copper




Unit Column
Size Distribution of Iron


Unit Column
Recovery to Concentrate

Test No. PP-22

Final Concentrate 0.293 kg/h

Particle Size		Solids			Copper			Iron		
µm	Mesh	% Ret. Indiv.	Rate kg/h	% Ret Cuml.	Assay %Cu	Distribution Indiv.	Distribution Cuml.	Assay %Fe	Distribution Indiv.	Distribution Cuml.
208	65	3.2	0.009	3.2	36.5	2.9	2.9	23.5	3.9	3.9
147	100	8.4	0.025	11.7	42.1	8.8	11.7	20.3	8.7	12.6
104	150	13.3	0.039	25.0	42.4	14.0	25.7	19.4	13.2	25.8
74	200	14.9	0.044	39.8	42.4	15.6	41.3	19.0	14.4	40.2
53	270	13.7	0.040	53.5	43.0	14.5	55.8	19.8	13.8	53.9
37	400	10.0	0.029	63.5	42.9	10.6	66.4	20.6	10.5	64.4
-37	Pan	36.5	0.107	100.0	37.2	33.6	100.0	19.1	35.6	100.0
Total		**100.0**	**0.293**	--	**40.4**	--	--	**19.6**	--	--
Direct					**41.5**			**20.1**		

Final Tails 194.25 kg/h

Particle Size		Solids			Copper			Iron		
µm	Mesh	% Ret. Indiv.	Rate kg/h	% Ret Cuml.	Assay %Cu	Distribution Indiv.	Distribution Cuml.	Assay %Fe	Distribution Indiv.	Distribution Cuml.
589	28	5.8	11.3	5.8	0.25	4.9	4.9	0.99	3.4	3.4
417	35	18.9	36.7	24.7	0.20	12.8	17.7	0.89	10.1	13.5
295	48	18.0	35.0	42.7	0.37	22.6	40.2	1.28	13.8	27.4
208	65	10.1	19.5	52.8	0.58	19.7	60.0	1.67	10.1	37.4
147	100	9.3	18.0	62.1	0.48	15.1	75.0	1.76	9.8	47.2
104	150	6.3	12.3	68.4	0.25	5.4	80.4	1.82	6.9	54.1
74	200	5.0	9.8	73.4	0.11	1.9	82.3	1.92	5.8	59.9
53	270	4.5	8.7	77.9	0.042	0.6	82.9	1.91	5.1	65.0
37	400	3.1	5.9	81.0	0.037	0.4	83.3	2.10	3.9	68.9
-37	Pan	19.0	36.9	100.0	0.26	16.7	100.0	2.73	31.1	100.0
Total		**100.0**	**194.2**	--	**0.30**	--	--	**1.67**	--	--
Direct					**0.26**			**1.41**		

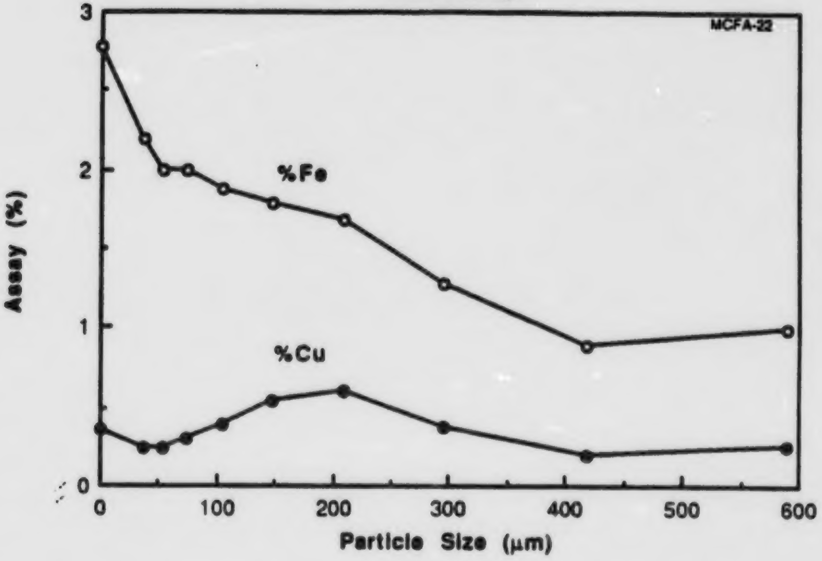
Test No. PP-22

Flotation Feed (calc) 194.54 kg/h

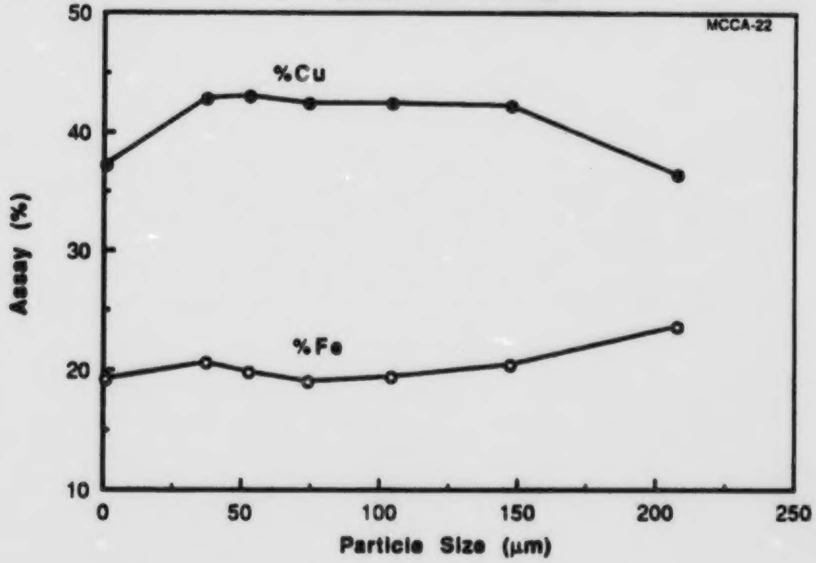
Particle Size		Solids			Copper			Iron		
		% Ret.	Rate	% Ret	Assay	Distribution		Assay	Distribution	
µm	Mesh	Indiv.	kg/h	Cuml.	%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
589	28	5.8	11.3	5.8	0.25	4.1	4.1	0.99	3.4	3.4
417	35	18.9	36.7	24.7	0.20	10.6	14.7	0.89	9.9	13.3
295	48	18.0	35.0	42.7	0.37	18.7	33.4	1.28	13.6	26.9
208	65	10.0	19.5	52.7	0.60	16.8	50.2	1.68	10.0	36.8
147	100	9.3	18.1	62.0	0.54	14.0	64.2	1.79	9.8	46.6
104	150	6.3	12.4	68.3	0.38	6.8	71.0	1.88	7.0	53.6
74	200	5.0	9.8	73.4	0.30	4.2	75.3	2.00	5.9	59.6
53	270	4.5	8.7	77.9	0.24	3.0	78.3	1.99	5.3	64.8
37	400	3.1	6.0	81.0	0.25	2.1	80.4	2.19	4.0	68.8
-37	Pan	19.0	37.0	100.0	0.37	19.6	100.0	2.78	31.2	100.0
Total		**100.0**	**194.5**	--	**0.36**	--	--	**1.70**	--	--
Direct					**0.26**			**1.41**		

Recovery to Concentrate

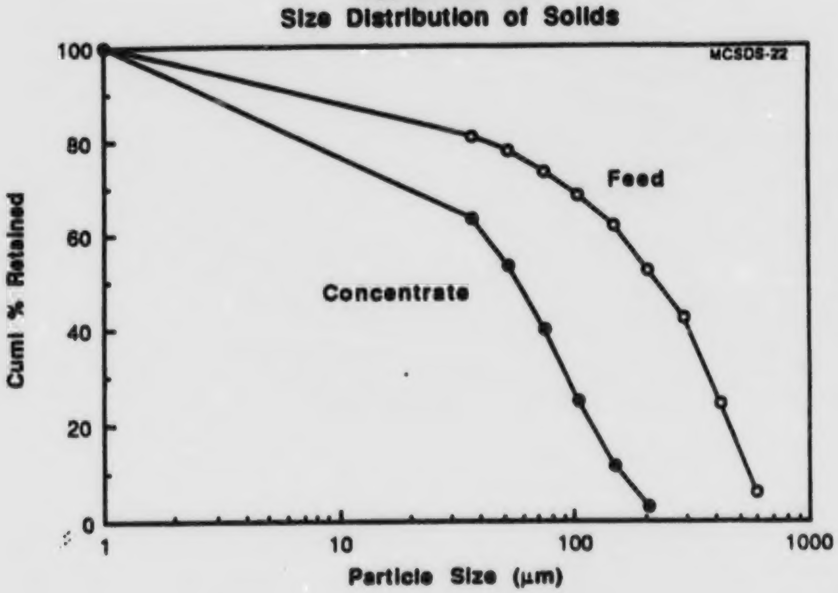
Particle Size		Recovery to Concentrate		
µm	Mesh	Sol	Cu	Fe
208	65	0.05	2.9	0.7
147	100	0.14	10.7	1.6
104	150	0.32	34.9	3.3
74	200	0.44	63.2	4.2
53	270	0.46	82.5	4.5
37	400	0.49	85.1	4.6
-37	Pan	0.29	29.3	2.0

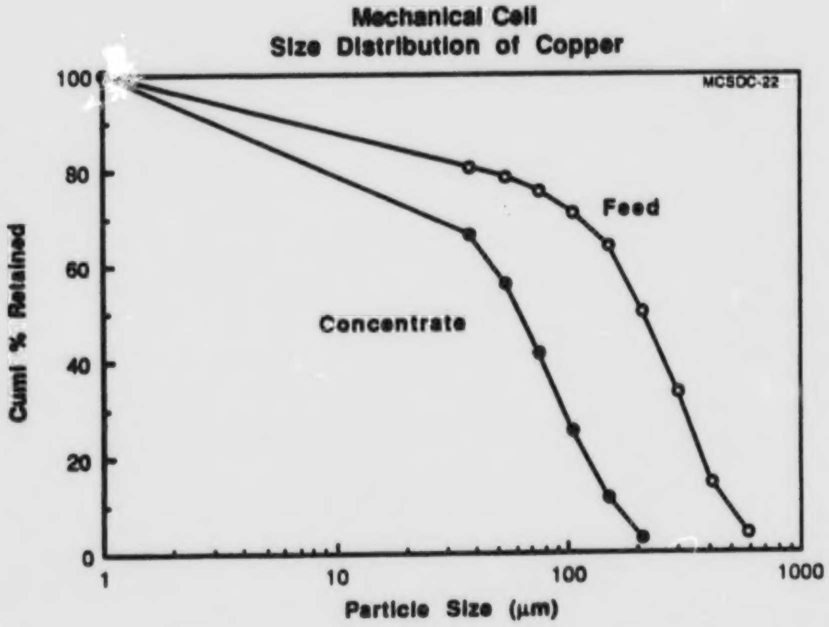


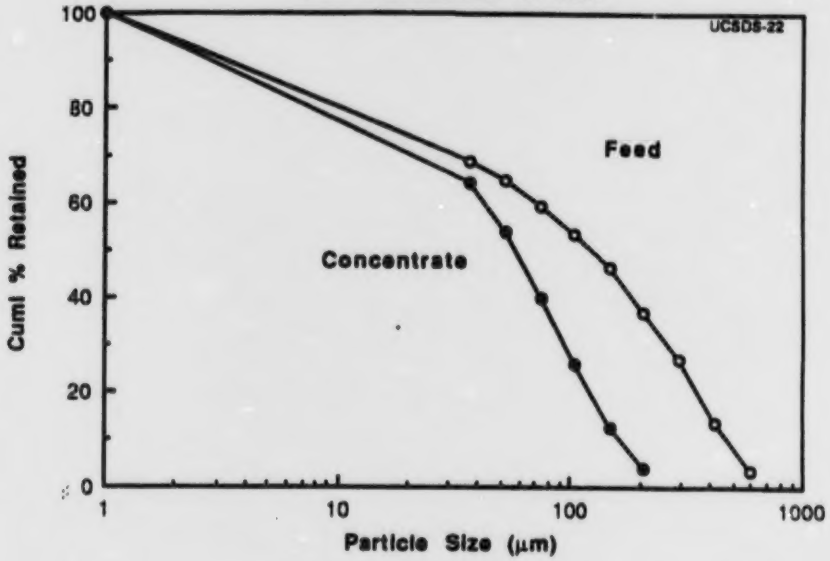
Mechanical Cell
Feed Assays



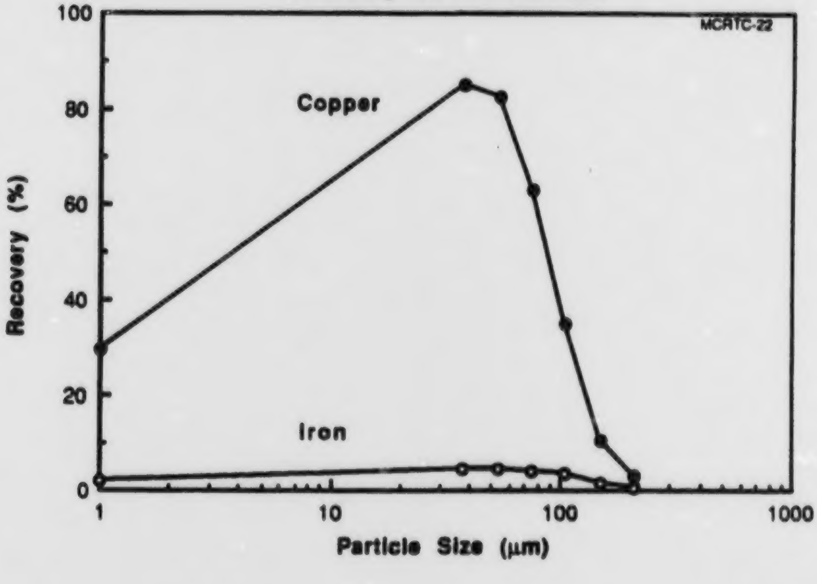
Mechanical Cell
Concentrate Assays


Mechanical Cell
Size Distribution of Solids
MCSDS-22
Cuml % Retained
100
80
60
40
20
0
Feed
Concentrate
1
10
100
1000
Particle Size (µm)


Mechanical Cell
Size Distribution of Copper
MCSDC-22
Cuml % Retained
100
80
60
40
20
0
Feed
Concentrate
1
10
100
1000
Particle Size (µm)



Mechanical Cell
Size Distribution of Iron



Mechanical Cell
Recovery to Concentrate

Test No. PP-23

1. **Purpose:** To operate a unit column flotation cell in the grinding circuit, to recover coarse copper minerals.

2. **Procedure:** No changes in flowsheet from test PP-10.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1a.

2.2. **Equipment:** The equipment list is shown in Table 1a.

3. **Results:**

Column Feed Size	11.5 % -100 mesh
Rod Mill Feed Grade	0.46 % Cu
Column Conc Grade	41.3 % Cu
Column Copper Rec'y.	36.2 %
Flotation Feed Size	47.6 % -100 mesh
Flotation Head Grade	0.29 % Cu
Final Tails Grade	0.18 % Cu
Flotation Copper Grade	38.7 % Cu
Flotation Copper Rec'y	36.2 %
Combined Grade	40.2 % Cu
Combined Recovery	60.8 %

In this final run for Phase One of the project, the circulating load was held at about 340%, and the circuit responded with much improved results, compared to the previous run at 500% circulating load. Overall copper recovery, however, was still unacceptable low at 61%.

3.1. Grinding Circuit Operation:

3.1.1. Rod Mill Report:

Feed:	191.8 kg/h	-1/4 inch	(Wet Sple 1229.1 g)
			(Dry Sple 1209.5 g)
Feed Rate:	188.7 kg/h	dry ore	(Moisture 1.59 %)
Mill Speed:	45 RPM		(85% of critical speed)
Rod Load:	100 kg		
Rod Mill Feed:	Total	992 kg in 5.17 hr	
	Sample	384 kg in 2.00 hr	
Rod Mill Discharge:	1,630 g/L		(61 % Sol at SG 2.75)
	60.7	% plus 48 mesh	
	26.8	% minus 100 mesh	
Input Power:	42.50	for 3 disc revolutions	
	0.91	kW (95% drive efficiency)	
Average Power:	0.87 kW	Gross	
	0.47 kW	No Load	
	0.39 kW	Net	
Net Power Usage:	2.09 kWh/t	of -1/4 inch feed	
K80 Feed:	4,107	microns	
K80 Product:	1,106	microns	
Work Index (metric):	14.5		

3.1.2. Ball Mill Report:

Feed:	Screen Oversize		(at 339 % circ. load)
Feed Rate:	639.4 kg/h		
Mill Speed:	40 RPM		(77% of critical speed)
Ball Load:	150 kg		
Screen Undersize:	1,110 g/L		(16 % Sol at SG 2.75)
Ball Mill Discharge:	89.2	% plus 48 mesh	
	6.9	% minus 100 mesh	
Input Power:	32.10	for 3 disc revolutions	
	1.21	kW (95% drive efficiency)	
Average Power:	1.15 kW	Gross	
	0.52 kW	No Load	
	0.63 kW	Net	
Net Power Usage:	0.98 kWh/t	of screen oversize	
K80 Feed:	1,106	microns	
K80 Product:	407	microns	
Work Index (metric):	5.0		

3.1.3. Overall Mill Report:

Net Power Usage:	3.07 kWh/t
K80 Feed:	4,107 microns
K80 Product:	407 microns
Work Index (metric):	9.1
Screen Undersize:	47.6 % -100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,107	15.1
Rod Mill Discharge	1,106	26.8
Column Feed	1,368	11.5
Column Conc	81	96.4
Column Tail	1,286	12.7
Ball Mill Feed	1,479	2.3
Ball Mill Discharge	1,424	6.9
Screen Undersize	407	47.6
Rougher Feed	412	56.7
Regrind Feed	~15	90.9
Regrind Discharge	~19	98.2
Final Concentrate	154	78.9
Final Tail	348	54.0

3.2. Reagent Additions:

Average Feed Rate: 0.189 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Ball Mill Discharge	PAX	0.10%	11.9	3.78
	DF-250	0.10%	8.2	2.61
	Pine Oil	100%	5.3 dr	15.16
Rougher Feed	PAX	0.10%	7.7	2.45
Scavenger Feed	PAX	0.10%	12.0	3.81
	DF-250	0.10%	2.0	0.64
	Pine Oil	0.10%	2.0	0.64
Scavenger Cell 4	PAX	0.10%	7.9	2.51
	DF-250	0.10%	3.8	1.21
Total	**PAX**			**12.56**
	DF-250			**4.45**
	Pine Oil			**15.80**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,630			2.75
Ball Mill Discharge				
Screen Feed	1,418			
Screen Undersize	1,110			
Rougher Feed		8.00	15.3	
Pre-Cleaner Feed		8.00		
Cleaner Feed		8.00		
Scavenger Tail	1,100			
Final Concentrate				

3.4. Estimated Residence Times:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Column	40	828.2	1,418	21.0	1.9
Rougher	84	191.7	1,110	18.5	4.5
Scavenger	168	189.5	1,105	19.1	8.8
Pre-Cleaner*	7.7		measured	1.1	7.0
Cleaner*	7.7		measured	1.0	7.7
Clnr/Scav*	7.7		measured	0.9	8.6

4. Metallurgical Results: (339% circulating load)

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

	Direct Assays		Adjusted Assays		Mass Flow
Product	% Cu	% Fe	% Cu	% Fe	kg/h
Rod Mill Feed	0.45	1.47	0.46	1.52	188.7
Rod Mill Discharge			0.46	1.52	188.7
Ball Mill Discharge	0.17	0.76	0.17	0.74	639.4
Column Feed			0.23	0.92	828.2
Column Conc	41.5	17.9	41.3	17.9	0.75
Column Tail (Scr Fd)	0.19	0.91.	0.20	0.90	827.4
Screen Oversize	0.17	0.72	0.17	0.74	639.4
Screen Undersize	0.30	1.54	0.29	1.46	188.0
Rougher Feed	0.32	1.77	0.32	1.49	191.7
Rougher Conc	10.7	7.63	10.4	7.3	2.18
Rougher Tail	0.20	1.80	0.20	1.43	189.5
Scav Tail (final)	0.18	1.46	0.18	1.41	187.4
Scavenger Conc	2.01	3.21	2.04	3.28	2.09
Pre-Cleaner Feed	9.10	6.99	10.1	7.5	2.52
Pre-Cleaner Conc	39.6	19.9	39.5	19.4	0.51
Pre-Cleaner Tail	2.25	4.07	2.61	4.50	2.01
Cleaner Feed	2.00	4.18	2.61	4.50	2.01
Cleaner Conc	27.7	14.8	27.6	14.8	0.04
Cleaner Tail	1.57	3.78	2.14	4.31	1.97
Clnr-Scav Conc	10.6	8.84	8.36	8.82	0.33
Clnr-Scav Tail	1.15	3.76	0.91	3.39	1.64
Flotation Conc	38.7	19.1	38.7	19.1	0.55
Combined Conc			40.2	18.4	1.30

4.2. Overall Metallurgical Balance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.00	0.46	1.52	100.0	100.0
Combined Conc	0.69	40.2	18.4	60.8	8.3
Final Tail	99.31	0.18	1.41	39.2	91.7
Column Feed	438.79	0.23	0.92	223.2	264.0
Conc	0.40	41.3	17.9	36.2	4.7
Tail	438.39	0.20	0.90	187.1	259.3
Flotation Feed	99.60	0.29	1.46	63.8	95.3
Conc	0.29	38.7	19.1	24.6	3.6
Tail	99.31	0.18	1.41	39.2	91.6
Rougher Feed	101.57	0.32	1.49	70.4	99.6
Conc	1.16	10.4	7.33	26.3	5.6
Tail	100.42	0.20	1.43	44.1	94.0
Scavenger Feed	100.42	0.20	1.43	44.0	94.0
Conc	1.11	2.04	3.28	4.9	2.4
Tail	99.31	0.18	1.41	39.1	91.6
Combined Clnr Feed	1.16	10.4	7.33	26.3	5.6
Flotation Conc	0.29	38.7	19.1	24.6	3.6
Clnr/Scav Tail	0.87	0.91	3.39	1.7	1.9
Pre-Cleaner Feed	1.33	10.1	7.53	29.5	6.6
Conc	0.27	39.5	19.4	23.4	3.4
Tail	1.06	2.61	4.50	6.1	3.1
Cleaner Feed	1.06	2.61	4.50	6.1	3.1
Conc	0.02	27.6	14.8	1.2	0.2
Tail	1.04	2.14	4.31	4.9	2.9
Clnr/Scav Feed	1.04	2.14	4.31	4.9	2.9
Conc	0.18	8.36	8.82	3.2	1.0
Tail	0.87	0.91	3.39	1.7	1.9

4.3. Individual Unit Performance:

Product	Overall Wt %	Assays		Distributions (%)	
		Cu	Fe	Cu	Fe
Rod Mill Feed	100.0	0.46	1.52	100.0	100.0
Combined Conc	0.69	40.2	18.4	60.8	8.3
Final Tail	99.3	0.18	1.41	39.2	91.7
Column Feed	100.0	0.23	0.92	100.0	100.0
Conc	0.09	41.3	17.9	16.2	1.8
Tail	99.9	0.20	0.90	83.8	98.2
Flotation Feed	100.0	0.29	1.46	100.0	100.0
Conc	0.29	38.7	19.1	38.6	3.8
Tail	99.7	0.18	1.41	61.4	96.2
Rougher Feed	100.0	0.32	1.49	100.0	100.0
Conc	1.14	10.4	7.3	37.4	5.6
Tail	98.9	0.20	1.43	62.6	94.4
Scavenger Feed	100.0	0.20	1.43	100.0	100.0
Conc	1.1	2.04	3.28	11.2	2.5
Tail	98.9	0.18	1.41	88.8	97.5
Combined Clnr Feed	100.0	10.4	7.3	100.0	100.0
Flotation Conc	25.1	38.7	19.1	93.5	65.4
Clnr/Scav Tail	74.9	0.91	3.39	6.5	34.6
Pre-Cleaner Feed	100.0	10.1	7.53	100.0	100.0
Conc	20.2	39.5	19.4	79.3	52.3
Tail	79.8	2.61	4.50	20.7	47.7
Cleaner Feed	100.0	2.61	4.50	100.0	100.0
Conc	1.88	27.6	14.8	19.9	6.2
Tail	98.1	2.14	4.31	80.1	93.8
Clnr/Scav Feed	100.0	2.14	4.31	100.0	100.0
Conc	16.95	8.36	8.82	66.2	34.7
Tail	83.0	0.91	3.39	33.8	65.3

5. Screen Analyses:

Detailed in the following pages.

Test No. PP-23

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	80.4	13.5	13.5	86.5
6	3,327	91.2	15.3	28.7	71.3
8	2,362	73.7	12.3	41.0	59.0
10	1,651	62.9	10.5	51.6	48.4
14	1,168	47.9	8.0	59.6	40.4
20	833	37.1	6.2	65.8	34.2
28	589	31.2	5.2	71.0	29.0
35	417	26.0	4.4	75.4	24.6
48	295	19.5	3.3	78.6	21.4
65	208	18.9	3.2	81.8	18.2
100	147	18.5	3.1	84.9	15.1
150	104	15.3	2.6	87.4	12.6
200	74	14.1	2.4	89.8	10.2
270	53	13.1	2.2	92.0	8.0
400	37	9.3	1.6	93.5	6.5
Pan	-37	38.6	6.5	100.0	-
Total	-	**597.7**	**100.0**	-	-
K80	**4,107**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	13.8	5.0	5.0	95.0
14	1,168	34.6	12.6	17.6	82.4
20	833	37.2	13.5	31.2	68.8
28	589	33.0	12.0	43.2	56.8
35	417	27.5	10.0	53.2	46.8
48	295	20.7	7.5	60.7	39.3
65	208	17.4	6.3	67.1	32.9
100	147	16.8	6.1	73.2	26.8
150	104	13.1	4.8	77.9	22.1
200	74	11.2	4.1	82.0	18.0
270	53	9.5	3.5	85.5	14.5
400	37	6.9	2.5	88.0	12.0
Pan	-37	33.0	12.0	100.0	-
Total	-	**274.7**	**100.0**	-	-
K80	**1,106**				

Column Feed (calculated)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	13.8	10.1	10.1	89.9
14	1,168	34.6	18.0	28.1	71.9
20	833	37.2	19.7	47.8	52.2
28	589	33.0	19.2	67.0	33.0
35	417	27.5	10.6	77.6	22.4
48	295	20.7	5.1	82.7	17.3
65	208	17.4	3.2	85.9	14.1
100	147	16.8	2.6	88.5	11.5
150	104	13.1	1.9	90.5	9.5
200	74	11.2	1.6	92.1	7.9
270	53	9.5	1.3	93.4	6.6
400	37	6.9	1.0	94.4	5.6
Pan	-37	33.0	5.6	100.0	-
Total	-	**274.7**	**100.0**	-	-
K80	**1,368**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	6.3	2.0	2.0	98.0
100	147	5.0	1.6	3.6	96.4
150	104	18.6	5.9	9.5	90.5
200	74	41.2	13.0	22.5	77.5
270	53	58.5	18.5	41.0	59.0
400	37	46.5	14.7	55.8	44.2
Pan	-37	139.7	44.2	100.0	-
Total	-	**315.8**	**100.0**	-	-
K80	**81.1**				

Test No. PP-23

Column Tails (Screen Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	28.8	8.1	8.1	91.9
14	1,168	57.7	16.2	24.3	75.7
20	833	68.7	19.3	43.5	56.5
28	589	69.9	19.6	63.1	36.9
35	417	41.1	11.5	74.7	25.3
48	295	20.7	5.8	80.5	19.5
65	208	13.1	3.7	84.2	15.8
100	147	11.1	3.1	87.3	12.7
150	104	8.0	2.2	89.5	10.5
200	74	6.2	1.7	91.2	8.8
270	53	5.4	1.5	92.8	7.2
400	37	4.0	1.1	93.9	6.1
Pan	-37	21.8	6.1	100.0	-
Total	-	**356.5**	**100.0**	-	-
K80	**1,286**				

Screen Oversize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	57.0	12.3	12.3	87.7
14	1,168	110.1	23.8	36.1	63.9
20	833	121.2	26.2	62.3	37.7
28	589	106.2	23.0	85.3	14.7
35	417	40.3	8.7	94.0	6.0
48	295	10.7	2.3	96.3	3.7
65	208	4.4	1.0	97.3	2.7
100	147	1.9	0.4	97.7	2.3
150	104	1.1	0.2	97.9	2.1
200	74	0.9	0.2	98.1	1.9
270	53	0.9	0.2	98.3	1.7
400	37	0.6	0.1	98.4	1.6
Pan	-37	7.2	1.6	100.0	-
Total	-	**462.5**	**100.0**	-	-
K80	**1,479**				

Test No. PP-23

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	63.5	11.6	11.6	88.4
14	1,168	107.0	19.6	31.2	68.8
20	833	117.5	21.5	52.7	47.3
28	589	116.7	21.3	74.0	26.0
35	417	58.8	10.8	84.8	15.2
48	295	24.1	4.4	89.2	10.8
65	208	12.7	2.3	91.5	8.5
100	147	8.6	1.6	93.1	6.9
150	104	6.0	1.1	94.2	5.8
200	74	4.6	0.8	95.0	5.0
270	53	3.7	0.7	95.7	4.3
400	37	3.1	0.6	96.3	3.7
Pan	-37	20.4	3.7	100.0	-
Total	-	**546.7**	**100.0**	-	-
K80	**1,424**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	5.0	4.0	4.0	96.0
35	417	18.9	15.1	19.1	80.9
48	295	15.1	12.1	31.2	68.8
65	208	13.4	10.7	41.9	58.1
100	147	13.1	10.5	52.4	47.6
150	104	10.3	8.2	60.6	39.4
200	74	8.9	7.1	67.7	32.3
270	53	7.8	6.2	73.9	26.1
400	37	5.9	4.7	78.7	21.3
Pan	-37	26.7	21.3	100.0	-
Total	-	**125.1**	**100.0**	-	-
K80	**407**				

Rougher Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	1.5	1.8	1.8	98.2
35	417	14.6	17.7	19.5	80.5
48	295	6.9	8.4	27.9	72.1
65	208	4.8	5.8	33.7	66.3
100	147	7.9	9.6	43.3	56.7
150	104	6.7	8.1	51.4	48.6
200	74	5.9	7.2	58.5	41.5
270	53	5.4	6.5	65.1	34.9
400	37	4.2	5.1	70.2	29.8
Pan	-37	24.6	29.8	100.0	-
Total	-	82.5	100.0	-	-
K80	412				

Pre-Cleaner Tail

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	0.0	0.0	0.0	100.0
65	208	1.0	8.3	8.3	91.7
100	147	0.1	0.8	9.1	90.9
150	104	0.1	0.8	9.9	90.1
200	74	0.2	1.7	11.6	88.4
270	53	0.2	1.7	13.2	86.8
400	37	0.2	1.7	14.9	85.1
Pan	-37	10.3	85.1	100.0	-
Total	-	12.1	100.0	-	-
K80	~15				

Cleaner Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.2	1.8	1.8	98.2
150	104	0.3	2.7	4.5	95.5
200	74	0.3	2.7	7.1	92.9
270	53	0.4	3.6	10.7	89.3
400	37	0.3	2.7	13.4	86.6
Pan	-37	9.7	86.6	100.0	-
Total	-	**11.2**	**100.0**	-	-
K80	**~19**				

Final Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	8.7	7.0	7.0	93.0
100	147	17.7	14.1	21.1	78.9
150	104	24.7	19.7	40.8	59.2
200	74	21.3	17.0	57.9	42.1
270	53	13.1	10.5	68.3	31.7
400	37	7.5	6.0	74.3	25.7
Pan	-37	32.1	25.7	100.0	-
Total	-	**125.1**	**100.0**	-	-
K80	**154**				

Scavenger Tail (final)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	2.4	2.1	2.1	97.9
35	417	14.6	12.6	14.7	85.3
48	295	12.2	10.5	25.2	74.8
65	208	11.2	9.7	34.9	65.1
100	147	12.8	11.1	46.0	54.0
150	104	10.2	8.8	54.8	45.2
200	74	8.8	7.6	62.4	37.6
270	53	7.9	6.8	69.2	30.8
400	37	5.8	5.0	74.2	25.8
Pan	-37	29.8	25.8	100.0	-
Total	-	**115.7**	**100.0**	-	-
K80	**348**				

Calculation of Circulating Load Ratio (CLR)

Weighted Average CLR 336.8 %

	Direct Screen Analyses				
Mesh	R.M.D.	Screen U/S	Screen O/S	B.M.D.	Scr Fd
10	5.0	0.0	12.3	11.6	0.0
14	12.6	0.0	23.8	19.6	0.0
20	13.5	0.0	26.2	21.5	0.0
28	12.0	4.0	23.0	21.3	0.0
35	10.0	15.1	8.7	10.8	0.0
48	7.5	12.1	2.3	4.4	0.0
65	6.3	10.7	1.0	2.3	2.0
100	6.1	10.5	0.4	1.6	1.6
150	4.8	8.2	0.2	1.1	5.9
200	4.1	7.1	0.2	0.8	13.0
270	3.5	6.2	0.2	0.7	18.5
400	2.5	4.7	0.1	0.6	0.0
Pan	12.0	21.3	1.6	3.7	59.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Mesh	Indiv CLR	Calc Scr Fd	Wt'd CLR
10	0 %	5.0	0.0
14	298 %	17.8	53.0
20	287 %	19.4	55.9
28	496 %	19.8	98.1
35	250 %	10.5	26.3
48	216 %	5.4	11.7
65	319 %	3.3	10.5
100	375 %	2.5	9.5
150	403 %	1.8	7.4
200	470 %	1.4	6.6
270	576 %	1.1	6.3
400	504 %	0.9	4.5
Pan	429 %	11.0	47.1
Total	**--**	**100.0**	**336.8 %**

Test No. PP-23

Unit Column Concentrate 0.755 kg/h

Particle Size		Solids			Copper			Iron		
µm	Mesh	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Cu Indiv.	Assay %Cu Cuml.	% Ret Cuml.	Assay %Fe Indiv.	Assay %Fe Cuml.	% Ret Cuml.
208	65	6.3	2.0	2.0	10.6	10.60	0.5	5.54	5.5	0.6
147	100	5.0	1.6	3.6	40.6	23.9	2.0	18.9	11.5	2.3
104	150	18.6	5.9	9.5	44.9	37.0	8.3	18.5	15.8	8.2
74	200	41.2	13.0	22.5	46.0	42.2	22.5	18.9	17.6	21.8
53	270	58.5	18.5	41.0	45.5	43.7	42.4	19.4	18.4	41.5
37	400	46.5	14.7	55.8	45.5	44.2	58.3	19.7	18.8	57.5
-37	Pan	139.7	44.2	100.0	39.9	42.3	100.0	17.5	18.2	100.0
Total		**315.8**	**100.0**	--	**42.3**	--	--	**18.2**	--	--
Direct					**41.5**			**17.9**		

Unit Column Tail (Screen Feed) 827.42 kg/h

Particle Size		Solids			Copper			Iron		
µm	Mesh	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Cu Indiv.	Assay %Cu Cuml.	% Ret Cuml.	Assay %Fe Indiv.	Assay %Fe Cuml.	% Ret Cuml.
1,651	10	28.8	8.1	8.1	0.16	0.16	6.3	0.68	0.68	5.9
1,168	14	57.7	16.2	24.3	0.13	0.14	16.7	0.64	0.65	17.1
833	20	68.7	19.3	43.5	0.13	0.14	29.0	0.66	0.66	30.7
589	28	69.9	19.6	63.1	0.15	0.14	43.4	0.64	0.65	44.3
417	35	41.1	11.5	74.7	0.20	0.15	54.7	0.79	0.67	54.1
295	48	20.7	5.8	80.5	0.32	0.16	63.8	1.07	0.70	60.7
208	65	13.1	3.7	84.2	0.41	0.17	71.2	1.27	0.73	65.8
147	100	11.1	3.1	87.3	0.53	0.19	79.3	1.63	0.76	71.2
104	150	8.0	2.2	89.5	0.55	0.19	85.4	1.84	0.79	75.7
74	200	6.2	1.7	91.2	0.36	0.20	88.4	1.84	0.81	79.1
53	270	5.4	1.5	92.8	0.21	0.20	90.0	1.90	0.82	82.2
37	400	4.0	1.1	93.9	0.18	0.20	91.0	1.87	0.84	84.5
-37	Pan	21.8	6.1	100.0	0.30	0.20	100.0	2.36	0.93	100.0
Total		**356.5**	**100.0**	--	**0.20**	--	--	**0.93**	--	--
Direct					**0.19**			**0.91**		

Screen Undersize (Flotation Feed) 187.99 kg/h

Particle Size		Solids			Copper			Iron		
		Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Cu		% Ret Cuml.	Assay %Fe		% Ret Cuml.
µm	Mesh				Indiv.	Cuml.		Indiv.	Cuml.	
589	28	5.0	4.0	4.0	0.13	0.13	1.9	0.57	0.57	1.6
417	35	18.9	15.1	19.1	0.21	0.19	13.3	0.71	0.68	8.9
295	48	15.1	12.1	31.2	0.25	0.22	24.3	0.92	0.77	16.4
208	65	13.4	10.7	41.9	0.35	0.25	37.8	1.17	0.87	25.0
147	100	13.1	10.5	52.4	0.43	1.03	54.1	1.35	3.51	34.6
104	150	10.3	8.2	60.6	0.46	0.83	67.8	1.57	2.81	43.4
74	200	8.9	7.1	67.7	0.33	0.71	76.3	1.83	2.57	52.3
53	270	7.8	6.2	73.9	0.22	0.62	81.2	1.88	2.45	60.3
37	400	5.9	4.7	78.7	0.15	0.57	83.8	1.75	2.37	65.9
-37	Pan	26.7	21.3	100.0	0.21	0.45	100.0	2.34	2.36	100.0
Total		**125.1**	**100.0**	--	**0.28**	--	--	**1.47**	--	--
Direct					**0.30**			**1.54**		

Final Concentrate 0.547 kg/h

Particle Size		Solids			Copper			Iron		
		Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Cu		% Ret Cuml.	Assay %Fe		% Ret Cuml.
µm	Mesh				Indiv.	Cuml.		Indiv.	Cuml.	
208	65	8.7	7.0	7.0	34.7	34.7	6.6	20.4	20.4	7.8
147	100	17.7	14.1	21.1	42.6	40.0	22.9	18.2	18.9	21.9
104	150	24.7	19.7	40.8	41.2	40.6	45.0	18.0	18.5	41.4
74	200	21.3	17.0	57.9	36.6	39.4	62.0	17.4	18.2	57.6
53	270	13.1	10.5	68.3	38.4	39.3	72.9	19.6	18.4	68.9
37	400	7.5	6.0	74.3	35.9	39.0	78.7	17.7	18.3	74.7
-37	Pan	32.1	25.7	100.0	30.5	36.8	100.0	18.0	18.2	100.0
Total		**125.1**	**100.0**	--	**36.8**	--	--	**18.2**	--	--
Direct					**38.7**			**19.1**		

Test No. PP-23

Final Tails 187.44 kg/h

Particle Size		Solids			Copper			Iron		
		Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Cu		% Ret Cuml.	Assay %Fe		% Ret Cuml.
µm	Mesh				Indiv.	Cuml.		Indiv.	Cuml.	
589	28	2.4	2.1	2.1	0.19	0.19	2.6	0.84	0.84	1.2
417	35	14.6	12.6	14.7	0.19	0.19	18.6	0.84	0.84	8.3
295	48	12.2	10.5	25.2	0.28	0.23	38.3	0.98	0.90	15.3
208	65	11.2	9.7	34.9	0.27	0.24	55.8	1.09	0.95	22.5
147	100	12.8	11.1	46.0	0.21	0.81	71.3	1.23	3.56	31.7
104	150	10.2	8.8	54.8	0.07	0.51	75.3	1.39	2.69	39.9
74	200	8.8	7.6	62.4	0.05	0.39	77.8	1.69	2.43	48.6
53	270	7.9	6.8	69.2	0.046	0.33	79.9	1.62	2.28	56.1
37	400	5.8	5.0	74.2	0.037	0.29	81.1	1.60	2.20	61.5
-37	Pan	29.8	25.8	100.0	0.11	0.22	100.0	2.21	2.20	100.0
Total		**115.7**	**100.0**	--	**0.15**	--	--	**1.48**	--	--
Direct					**0.18**			**1.46**		

Test No. PP-23

Unit Column Concentrate 0.755 kg/h

Particle Size		Solids			Copper			Iron		
		% Ret.	Rate	% Ret	Assay	Distribution		Assay	Distribution	
µm	Mesh	Indiv.	kg/h	Cuml.	%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
208	65	2.0	0.015	2.0	10.6	0.5	0.5	5.54	0.6	0.6
147	100	1.6	0.012	3.6	40.6	1.5	2.0	18.9	1.6	2.3
104	150	5.9	0.044	9.5	44.9	6.3	8.3	18.5	6.0	8.2
74	200	13.0	0.098	22.5	46.0	14.2	22.5	18.9	13.5	21.8
53	270	18.5	0.140	41.0	45.5	19.9	42.4	19.4	19.7	41.5
37	400	14.7	0.111	55.8	45.5	15.8	58.3	19.7	15.9	57.5
-37	Pan	44.2	0.334	100.0	39.9	41.7	100.0	17.5	42.5	100.0
Total		**100.0**	**0.755**	--	**42.3**	--	--	**18.2**	--	--
Direct					**41.5**			**17.9**		

Unit Column Tail (Screen Feed) 827.42 kg/h

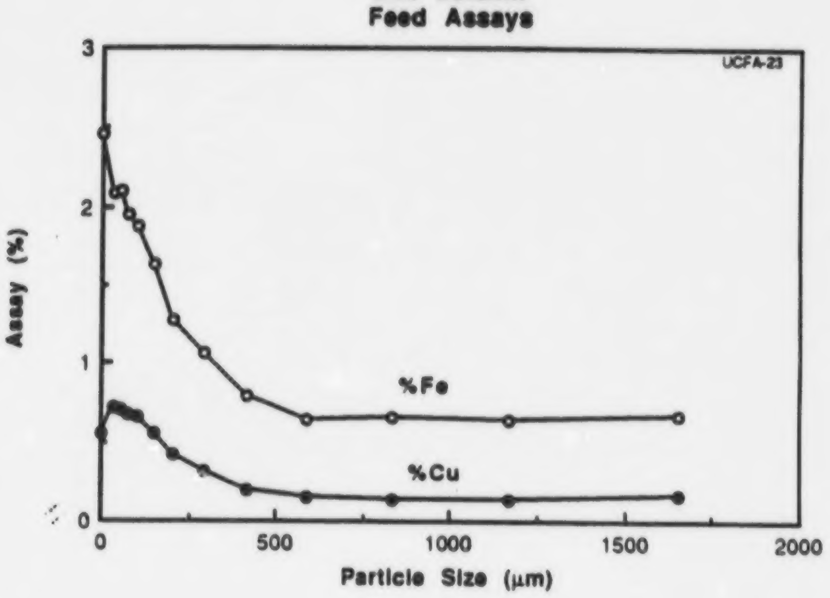
Particle Size		Solids			Copper			Iron		
		% Ret.	Rate	% Ret	Assay	Distribution		Assay	Distribution	
µm	Mesh	Indiv.	kg/h	Cuml.	%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
1,651	10	8.1	66.8	8.1	0.16	6.3	6.3	0.68	5.9	5.9
1,168	14	16.2	133.9	24.3	0.13	10.3	16.7	0.64	11.1	17.1
833	20	19.3	159.4	43.5	0.13	12.3	29.0	0.66	13.7	30.7
589	28	19.6	162.2	63.1	0.15	14.4	43.4	0.64	13.5	44.3
417	35	11.5	95.4	74.7	0.20	11.3	54.7	0.79	9.8	54.1
295	48	5.8	48.0	80.5	0.32	9.1	63.8	1.07	6.7	60.7
208	65	3.7	30.4	84.2	0.41	7.4	71.2	1.27	5.0	65.8
147	100	3.1	25.8	87.3	0.53	8.1	79.3	1.63	5.5	71.2
104	150	2.2	18.6	89.5	0.55	6.1	85.4	1.84	4.4	75.7
74	200	1.7	14.4	91.2	0.36	3.1	88.4	1.84	3.4	79.1
53	270	1.5	12.5	92.8	0.21	1.6	90.0	1.90	3.1	82.2
37	400	1.1	9.3	93.9	0.18	1.0	91.0	1.87	2.3	84.5
-37	Pan	6.1	50.6	100.0	0.30	9.0	100.0	2.36	15.5	100.0
Total		**100.0**	**827**	--	**0.20**	--	--	**0.93**	--	--
Direct					**0.19**			**0.91**		

Unit Column Feed (calc) **828.17 kg/h**

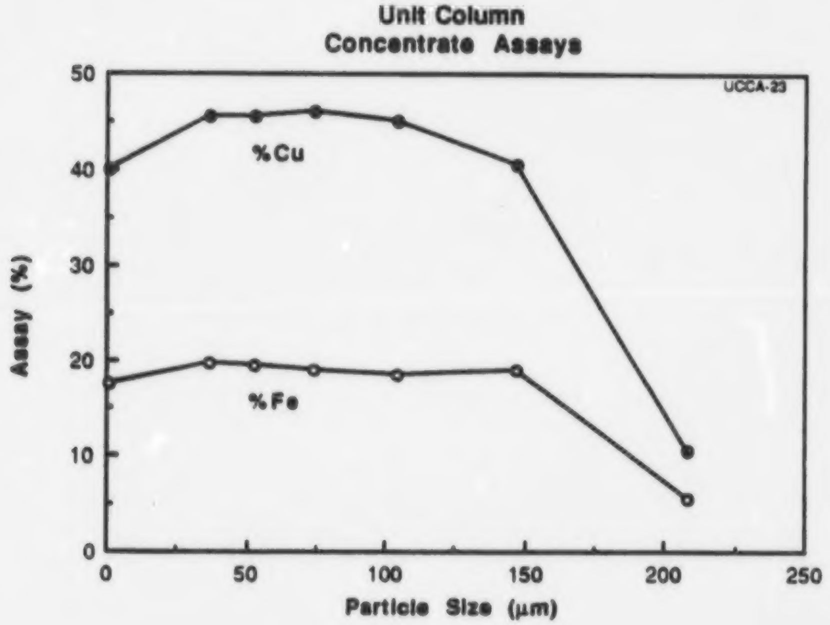
Particle Size		Solids			Copper			Iron		
		% Ret. Indiv.	Rate kg/h	% Ret Cuml.	Assay	Distribution		Assay	Distribution	
µm	Mesh				%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
1,651	10	8.1	66.8	8.1	0.16	5.3	5.3	0.68	5.8	5.8
1,168	14	16.2	133.9	24.2	0.13	8.7	14.0	0.64	11.0	16.8
833	20	19.3	159.4	43.5	0.13	10.3	24.4	0.66	13.4	30.2
589	28	19.6	162.2	63.1	0.15	12.1	36.5	0.64	13.3	43.5
417	35	11.5	95.4	74.6	0.20	9.5	46.0	0.79	9.6	53.1
295	48	5.8	48.0	80.4	0.32	7.7	53.7	1.07	6.6	59.7
208	65	3.7	30.4	84.1	0.42	6.3	60.0	1.27	4.9	64.6
147	100	3.1	25.8	87.2	0.55	7.1	67.0	1.64	5.4	70.0
104	150	2.2	18.6	89.4	0.66	6.1	73.1	1.88	4.5	74.5
74	200	1.7	14.5	91.2	0.67	4.8	77.9	1.96	3.6	78.1
53	270	1.5	12.7	92.7	0.71	4.5	82.4	2.09	3.4	81.5
37	400	1.1	9.4	93.9	0.72	3.4	85.8	2.08	2.5	84.0
-37	Pan	6.1	50.9	100.0	0.56	14.2	100.0	2.46	16.0	100.0
Total		**100.0**	**828**	--	**0.24**	--	--	**0.94**	--	--
Direct					**0.23**			**0.92**		

Recovery to Concentrate

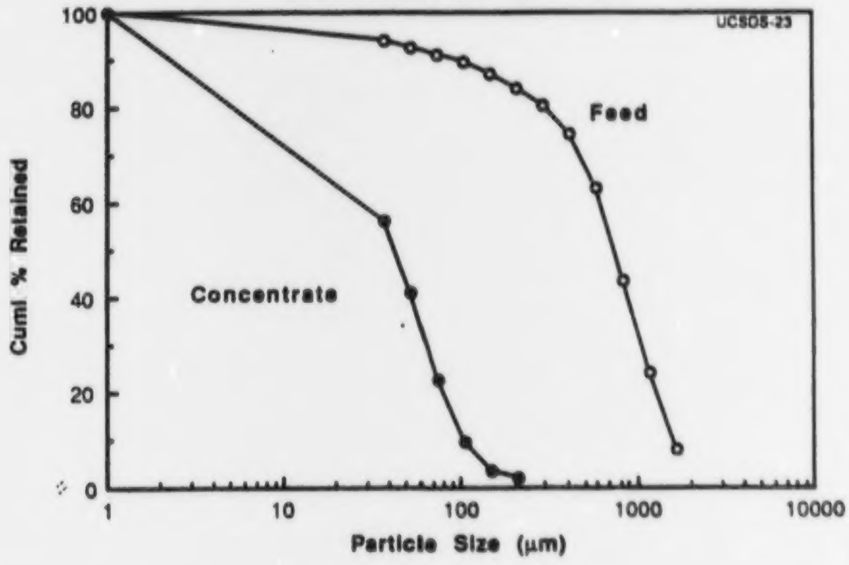
Particle Size		Recovery to Concentrate		
µm	Mesh	Sol	Cu	Fe
208	65	0.05	1.26	0.22
147	100	0.05	3.43	0.54
104	150	0.24	16.4	2.35
74	200	0.68	46.7	6.57
53	270	1.10	70.7	10.2
37	400	1.18	75.2	11.2
-37	Pan	0.66	46.7	4.67



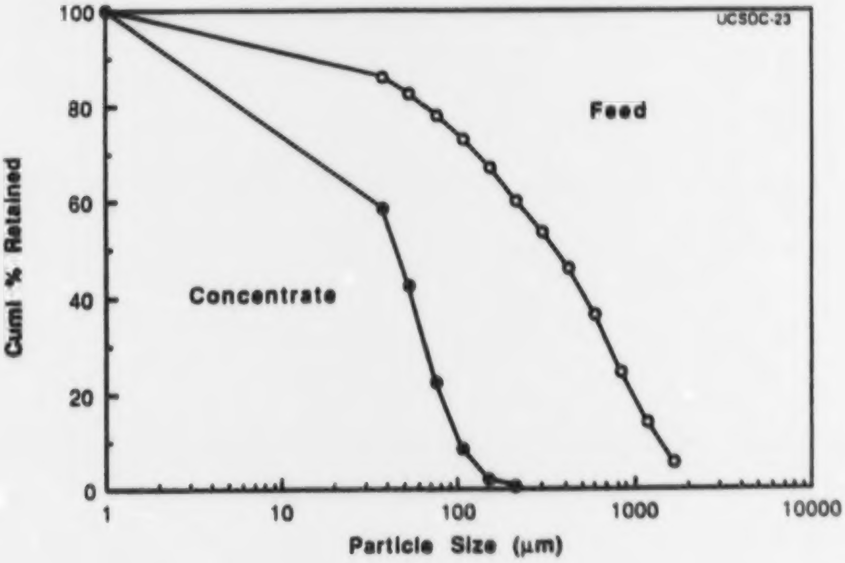
Unit Column
Feed Assays



Unit Column
Concentrate Assays

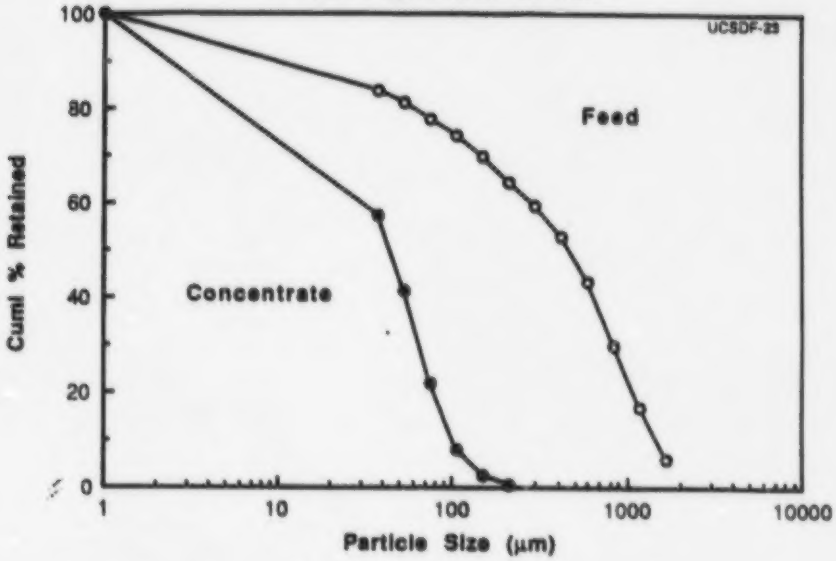


Unit Column
Size Distribution of Solids

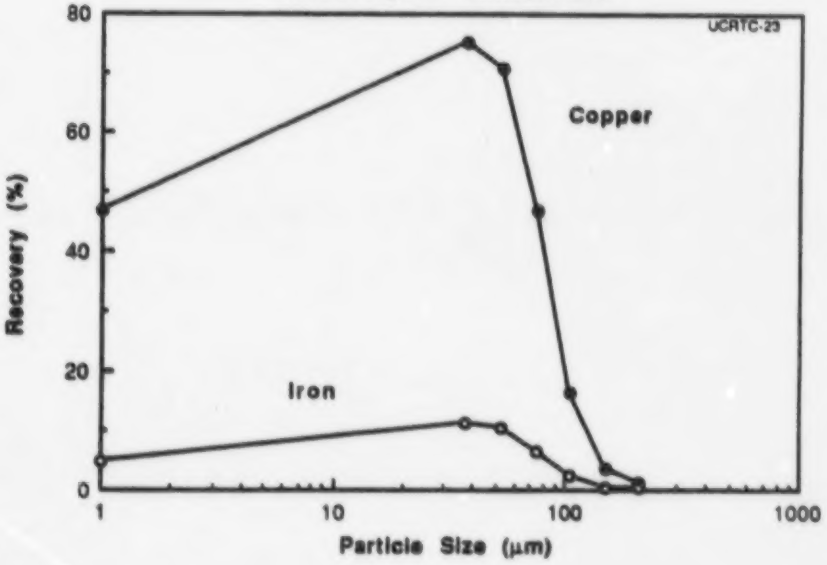


Unit Column
Size Distribution of Copper

Unit Column
Size Distribution of Iron



Unit Column
Recovery to Concentrate



Final Concentrate 0.547 kg/h

Particle Size		Solids			Copper			Iron		
		% Ret.	Rate	% Ret	Assay	Distribution		Assay	Distribution	
µm	Mesh	Indiv.	kg/h	Cuml.	%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
208	65	7.0	0.038	7.0	34.7	6.6	6.6	20.4	7.8	7.8
147	100	14.1	0.077	21.1	42.6	16.4	22.9	18.2	14.1	21.9
104	150	19.7	0.108	40.8	41.2	22.1	45.0	18.0	19.5	41.4
74	200	17.0	0.093	57.9	36.6	16.9	62.0	17.4	16.2	57.6
53	270	10.5	0.057	68.3	38.4	10.9	72.9	19.6	11.3	68.9
37	400	6.0	0.033	74.3	35.9	5.8	78.7	17.7	5.8	74.7
-37	Pan	25.7	0.140	100.0	30.5	21.3	100.0	18.0	25.3	100.0
Total		**100.0**	**0.547**	--	**36.8**	--	--	**18.2**	--	--
Direct					**38.7**			**19.1**		

Final Tails 187.44 kg/h

Particle Size		Solids			Copper			Iron		
		% Ret.	Rate	% Ret	Assay	Distribution		Assay	Distribution	
µm	Mesh	Indiv.	kg/h	Cuml.	%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
589	28	2.1	3.9	2.1	0.19	2.6	2.6	0.84	1.2	1.2
417	35	12.6	23.7	14.7	0.19	16.0	18.6	0.84	7.2	8.3
295	48	10.5	19.8	25.2	0.28	19.7	38.3	0.98	7.0	15.3
208	65	9.7	18.1	34.9	0.27	17.4	55.8	1.09	7.1	22.5
147	100	11.1	20.7	46.0	0.21	15.5	71.3	1.23	9.2	31.7
104	150	8.8	16.5	54.8	0.07	4.1	75.3	1.39	8.3	39.9
74	200	7.6	14.3	62.4	0.05	2.4	77.8	1.69	8.7	48.6
53	270	6.8	12.8	69.2	0.046	2.1	79.9	1.62	7.5	56.1
37	400	5.0	9.4	74.2	0.037	1.2	81.1	1.60	5.4	61.5
-37	Pan	25.8	48.3	100.0	0.11	18.9	100.0	2.21	38.5	100.0
Total		**100.0**	**187.4**	--	**0.15**	--	--	**1.48**	--	--
Direct					**0.18**			**1.46**		

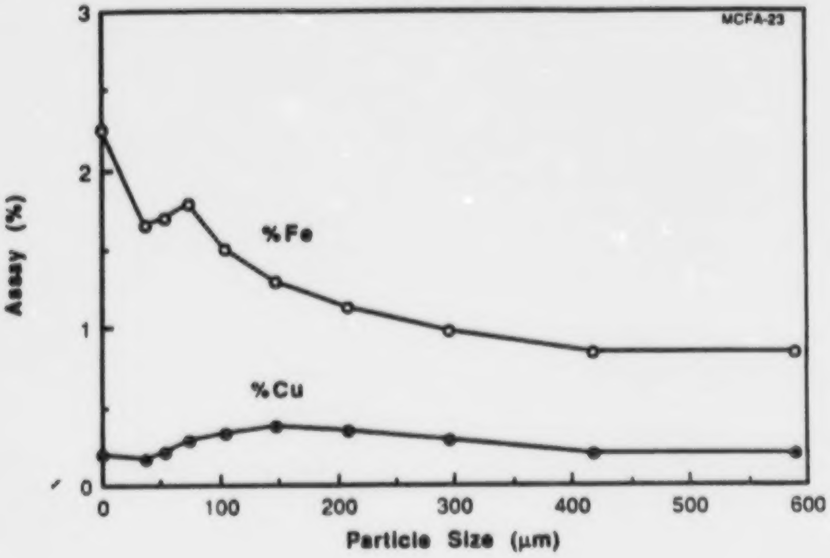
Flotation Feed (calc) 187.99 kg/h

Particle Size		Solids			Copper			Iron		
		% Ret.	Rate	% Ret	Assay	Distribution		Assay	Distribution	
µm	Mesh	Indiv.	kg/h	Cuml.	%Cu	Indiv.	Cuml.	%Fe	Indiv.	Cuml.
589	28	2.1	3.9	2.1	0.19	1.5	1.5	0.84	1.1	1.1
417	35	12.6	23.7	14.7	0.19	9.3	10.8	0.84	6.9	8.1
295	48	10.5	19.8	25.2	0.28	11.5	22.3	0.98	6.7	14.8
208	65	9.7	18.2	34.8	0.34	12.9	35.2	1.13	7.2	21.9
147	100	11.1	20.8	45.9	0.37	15.9	51.1	1.29	9.4	31.3
104	150	8.8	16.6	54.8	0.34	11.6	62.7	1.50	8.7	40.0
74	200	7.6	14.3	62.4	0.29	8.5	71.2	1.79	9.0	48.9
53	270	6.8	12.9	69.2	0.22	5.8	76.9	1.70	7.6	56.5
37	400	5.0	9.4	74.2	0.16	3.2	80.1	1.66	5.4	62.0
-37	Pan	25.8	48.4	100.0	0.20	19.9	100.0	2.26	38.0	100.0
Total		**100.0**	**188.0**	--	**0.26**	--	--	**1.53**	--	--
Direct					**0.30**			**1.54**		

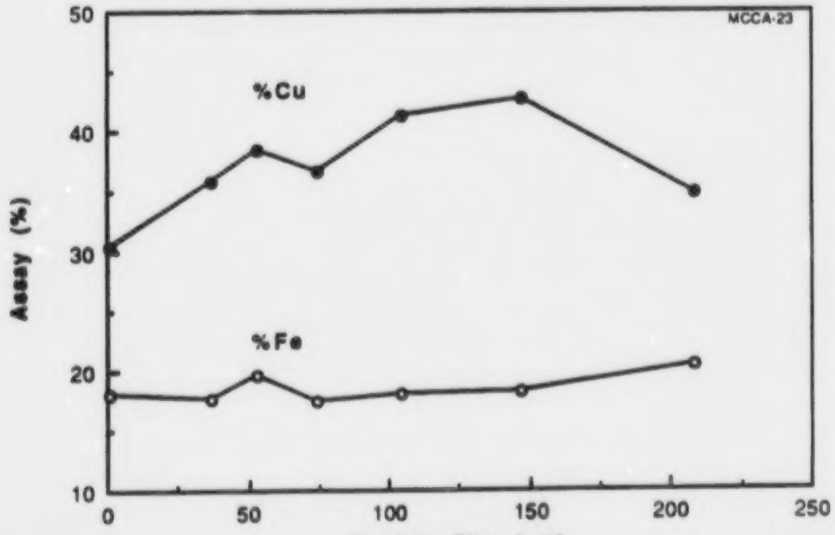
Recovery to Concentrate

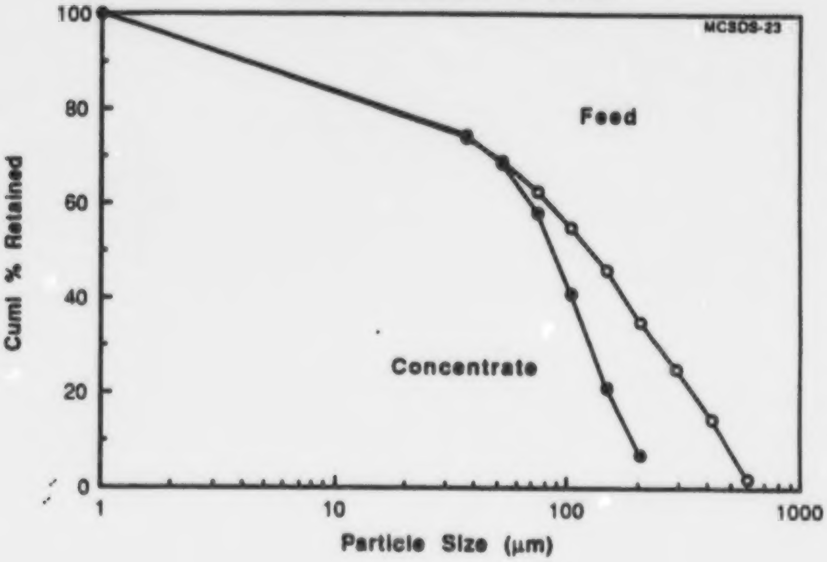
Particle Size		Recovery to Concentrate		
µm	Mesh	Sol	Cu	Fe
208	65	0.21	21.2	3.8
147	100	0.37	43.1	5.2
104	150	0.65	79.6	7.8
74	200	0.65	83.3	6.3
53	270	0.45	78.9	5.1
37	400	0.35	77.2	3.7
-37	Pan	0.29	44.6	2.3

Mechanical Cell
Feed Assays

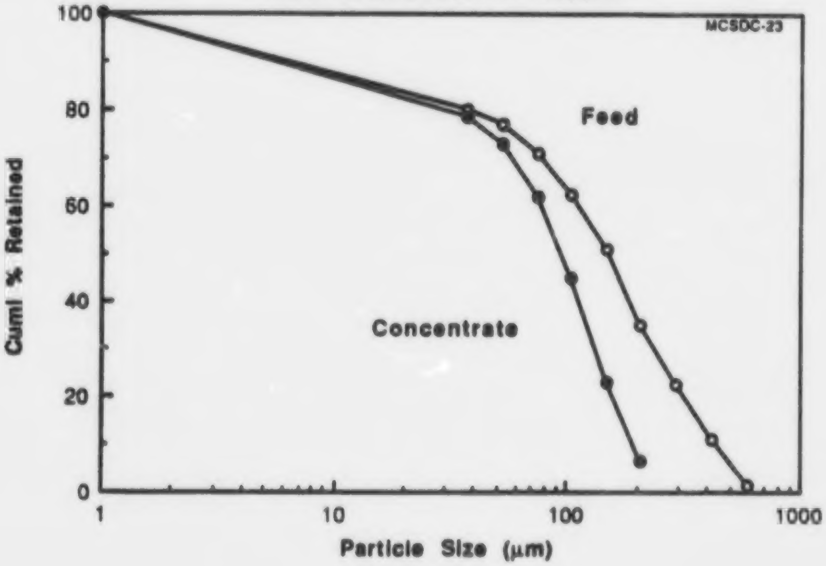


Mechanical Cell
Concentrate Assays

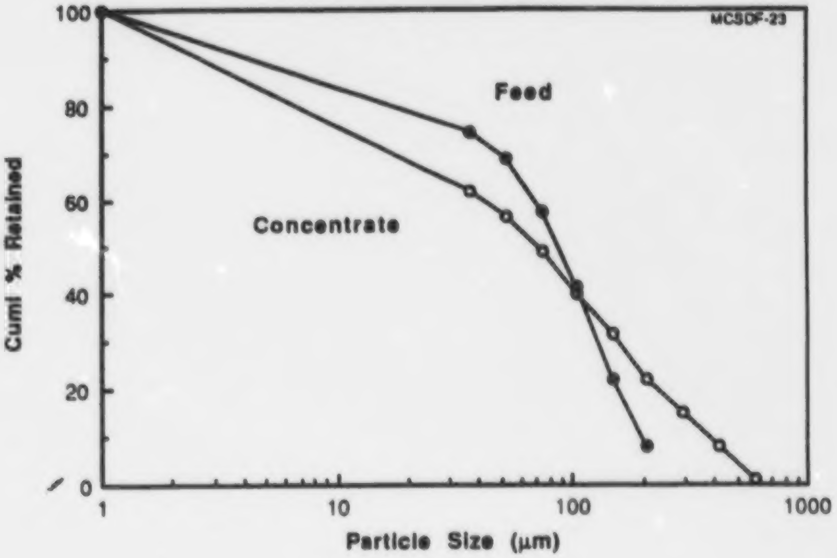




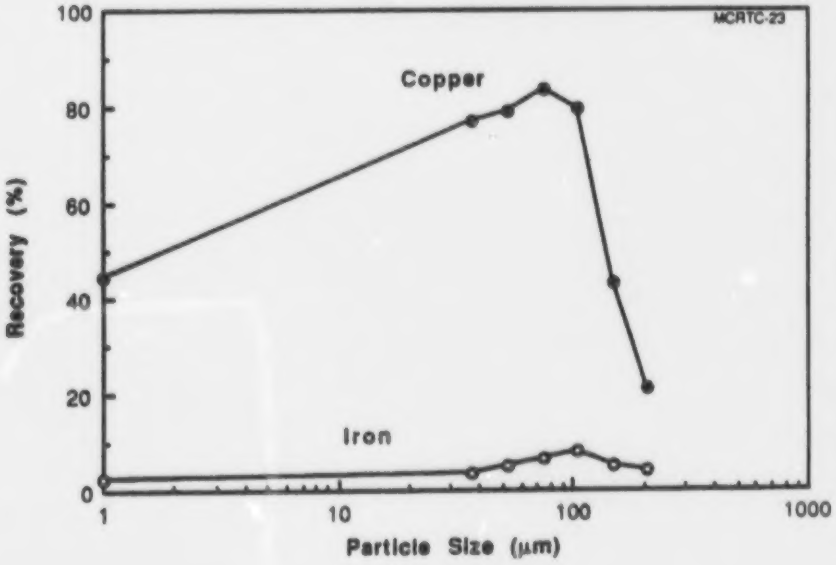
Mechanical Cell
Size Distribution of Solids



Mechanical Cell
Size Distribution of Copper



Mechanical Cell
Size Distribution of Iron



Mechanical Cell
Recovery to Concentrate

Volume

3

CONTRACT SERIAL NO. 99131-01-SQ

CONTRACT REQUISITION NO. 23440-9-9131

CONTRACTOR: LAKEFIELD RESEARCH

UNIT COLUMN FLOTATION

Of Highland Valley Copper
and
Falconbridge Strathcona Ores

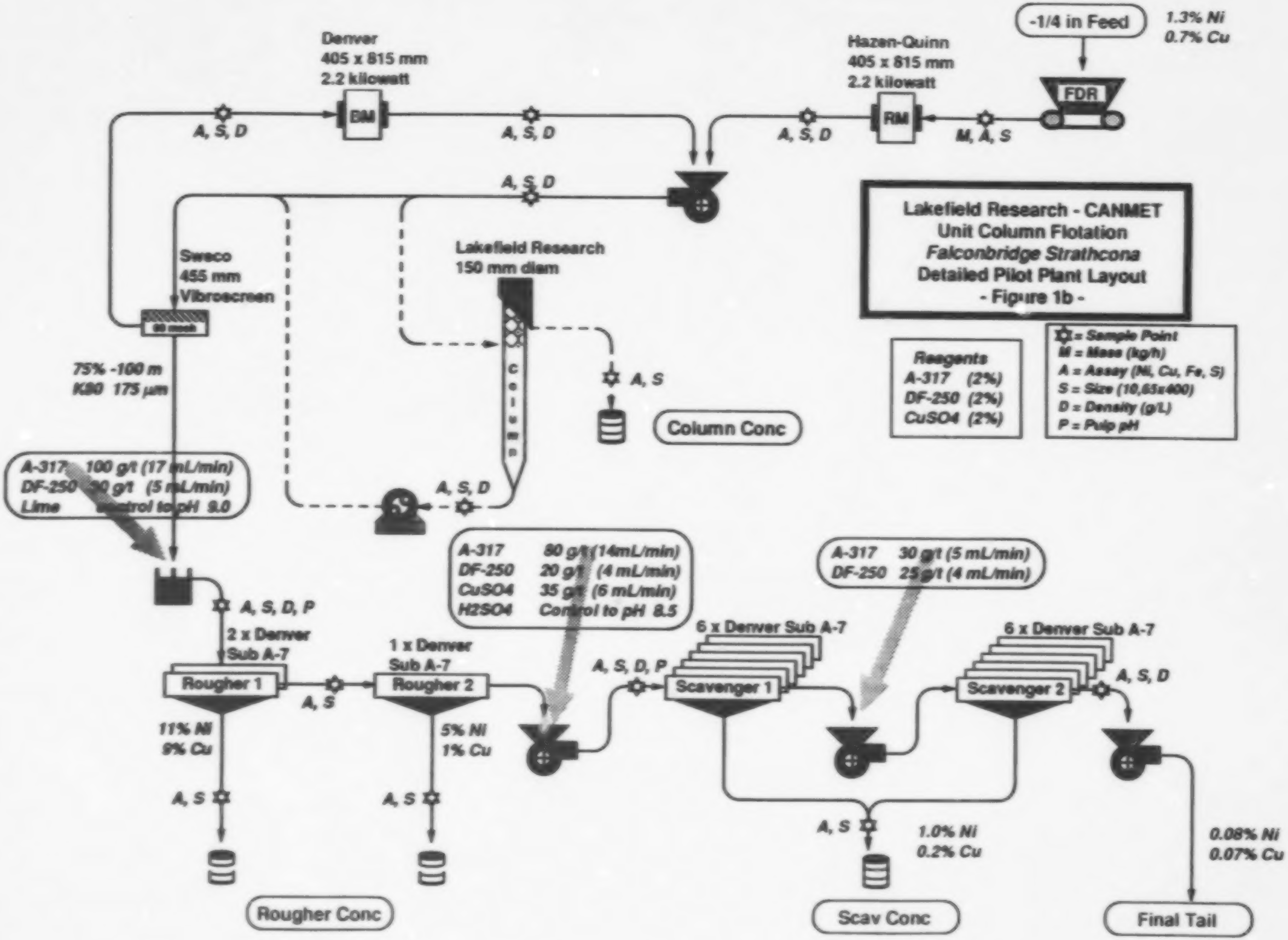
Volume 3 - Final Report

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology (CANMET), Energy Mines and Resources, Canada

Lakefield Research Project Number: LR-3897

DSS File Number : 003SQ.23440-9-9131
DSS Contract Number : 23440-9-9131/01-SQ
CANMET Scientific Authority : Kwang S. Moon, PhD.

LAKEFIELD RESEARCH
A Division of Falconbridge Limited
December 18th, 1990



Lakefield Research - CANMET
Unit Column Flotation
Falconbridge Strathcona
Detailed Pilot Plant Layout
- Figure 1b -

Table 1b - Phase Two Equipment List

Rod Mill	Hazen-Quinn 405 mm x 815 mm 2.2 kilowatt
Ball Mill	Denver 405 mm x 815 mm 2.2 kilowatt
Primary Screen	Sweco Vibroscreen 760 mm diameter
Unit Column	Lakefield Research 150 mm diameter 3.65 meter high 65 liter
Primary Conditioner	Denver 20 liter
Primary Rougher	2 x Denver Sub A-7 28 liter per cell 0.37 kW per cell
Secondary Rougher	1 x Denver Sub A-7 28 liter per cell 0.37 kW per cell
Scavenger Flotation	12 x Denver Sub A-7 28 liter per cell 0.37 kW per cell

Mill Feed Summary **Rod Mill Summary**

Test	Date	Mill Feed					Rod	Screen	Feed	Disch.	Rod Mill Discharge				Net	Work
	Month -Day	Wet kg/h	Dry kg/h	Moist %	Shift kg	Total tonnes	Charge kg	Size mesh	K80 µm	K80 µm	Density g/L	Density % Sol	% + 48 m	% - 100 m	Power kWh/t	Index metric
PP-24	05-24	193.8	190.0	2.0	484	0.5	160	60	3,325	861	1,660	56	46.5	40.2	2.93	17.5
PP-25	05-28	205.3	204.0	0.6	513	1.0	160	60	4,529	714	1,690	58	44.5	40.5	2.54	11.3
PP-26	05-30	197.3	194.4	1.5	1,036	2.0	160	60	3,221	738	1,600	53	47.4	37.3	2.96	15.4
PP-27	06-04	208.8	207.6	0.6	574	2.6	160	60	3,206	714	1,600	54	41.9	42.8	2.54	12.9
PP-28	06-16	199.3	195.0	2.2	548	3.2	160	60	3,680	572	1,670	57	40.7	42.0	3.67	14.5
PP-29	06-17	192.8	192.1	0.4	1,157	4.3	160	60	4,143	472	1,692	57	34.7	45.6	3.22	10.5
PP-30	06-18	195.8	193.0	1.4	1,224	5.5	160	60	4,140	546	1,702	59	39.5	42.9	3.21	11.8
PP-31	08-27	196.4	194.5	1.0	1,031	6.6	160	60	3,840	584	1,473	46	41.8	40.7	2.76	10.9
PP-32	08-27	199.9	196.6	1.7	1,399	8.0	160	60	4,233	619	1,575	52	42.4	41.3	2.94	11.8
PP-33	08-28	195.2	193.6	0.8	765	8.7	160	60	4,040	584	1,560	52	40.3	42.5	3.08	12.0
PP-34	08-28	199.1	196.6	1.3	996	9.7	160	60	4,420	537	1,638	55	37.3	44.1	3.00	10.7
PP-35	08-28	202.9	200.8	1.0	507	10.2	160	60	4,700	642	1,680	57	42.1	42.3	3.20	12.9
PP-36	08-29	193.3	191.1	1.1	837	11.1	160	60	3,932	629	1,698	58	41.0	42.1	3.36	14.1
PP-37	08-29	199.1	197.0	1.1	995	12.1	160	60	4,486	802	1,680	57	47.9	38.2	3.14	15.4
PP-38	08-29	193.3	190.5	1.4	837	12.9	160	60	4,577	759	1,650	56	46.9	37.9	3.19	14.8
PP-39	08-30	194.5	192.6	1.0	860	13.8	160	60	3,983	553	1,710	59	40.0	42.7	3.26	12.2
PP-40	08-30	195.4	192.7	1.4	864	14.6	160	60	4,401	516	1,690	58	38.6	43.2	3.22	11.1
PP-41	08-30	201.7	199.0	1.3	892	15.5	160	60	4,681	759	1,737	61	47.1	38.2	3.22	14.9
Avg		**198.0**	**195.6**	**1.2**	--	--	--	--	**4,085**	**645**	**1,650**	**56**	**42.3**	**41.4**	**3.1**	**13.0**
Max		208.8	207.6	2.2	--	--	--	--	4,700	861	1,737	61	47.9	45.6	3.7	17.5
Min		192.8	190.0	0.4	--	--	--	--	3,206	472	1,473	46	34.7	37.3	2.5	10.5
%S.D.		2.3%	2.4%	39%	--	--	--	--	11.8%	17.1%	4.0%	6.2%	8.9%	5.5%	9.0%	15.5%

Ball Mill Summary

Test	Ball Charge kg	Feed Rate kg/h	Feed K80 µm	Final K80 µm	Ball Mill Discharge				Circ Load %	Net Power kWh/t	Work Index metric
					Density		% +	% -			
					g/L	% Sol	48 m	100 m			
PP-24	100	889.4	861	165	1,660	56	74.1	13.2	468	--	--
PP-25	100	1,254	714	151	2,053	73	74.9	12.8	615	--	--
PP-26	100	940.7	738	169	--	--	68.4	14.1	484	--	--
PP-27	100	1,640	714	148	1,627	55	76.2	8.5	790	--	--
PP-28	100	162.0	572	145	1,730	60	9.5	66.4	83	3.32	8.0
PP-29	100	407.2	472	153	1,844	64	52.7	20.0	212	1.44	4.1
PP-30	100	283.0	546	140	1,778	62	50.9	20.1	147	1.95	4.7
PP-31	100	1,329	584	153	1,678	57	76.4	5.9	683	0.61	1.5
PP-32	100	446.4	619	155	1,975	70	76.8	4.4	227	1.60	4.0
PP-33	100	767.8	584	181	1,590	53	70.8	9.9	397	1.07	3.2
PP-34	100	467.5	537	166	1,815	64	63.4	15.2	242	1.60	4.6
PP-35	100	1,025	642	192	1,940	69	82.5	5.6	511	0.92	2.8
PP-36	100	530.0	629	185	1,592	53	81.3	5.3	277	1.78	5.3
PP-37	100	970.8	802	110	1,740	60	79.1	6.7	493	0.93	1.6
PP-38	100	396.3	759	156	1,993	71	66.0	15.7	208	2.05	4.7
PP-39	100	379.3	553	173	1,462	45	65.1	15.4	197	2.08	6.2
PP-40	100	553.5	516	150	1,547	50	76.9	2.8	287	1.48	3.9
PP-41	100	593.4	759	138	1,950	70	70.8	12.9	298	1.40	2.9
Avg	**–**	**724.2**	**645**	**157**	**1,763**	**61**	**67.5**	**14.2**	**368**	**1.59**	**4.1**
Max	--	1,640	861	192	2,053	73	82.5	66.4	790	3.32	8.0
Min	--	162.0	472	110	1,462	45	9.5	2.8	83	0.61	1.5
%SD	--	56%	17%	12%	10%	13%	25%	99%	54%	42%	42%

Overall Grinding

Test	Screen Undersize			Net Power kWh/t	Work Index metric
	Dens g/L	Dens. % Sol	% - 100 m		
PP-24	--	--	75.2	--	--
PP-25	1,170	21	79.0	--	--
PP-26	1,150	18	74.1	--	--
PP-27	1,237	27	79.8	--	--
PP-28	1,347	37	80.6	6.99	10.5
PP-29	1,274	30	78.5	4.65	7.1
PP-30	1,262	29	81.6	5.15	7.5
PP-31	1,160	20	78.4	3.38	5.2
PP-32	1,191	23	77.8	4.54	7.0
PP-33	1,590	53	70.8	4.14	7.1
PP-34	1,170	21	75.1	4.60	7.4
PP-35	1,150	19	68.4	4.12	7.2
PP-36	1,174	21	69.5	5.14	8.9
PP-37	1,163	20	87.2	4.07	5.1
PP-38	1,200	24	77.6	5.24	8.0
PP-39	1,186	22	73.5	5.34	8.9
PP-40	1,175	21	79.3	4.70	7.1
PP-41	1,173	21	82.0	4.63	6.6
Avg	**1,222**	**25**	**77.1**	**4.76**	**7.4**
Max	1,590	53	87.2	6.99	10.5
Min	1,150	18	68.4	3.38	5.1
%SD	9%	35%	6%	18%	19%

Reagent Summary

Pulp Conditions

Test	Column Feed			Rougher Feed				1st Scavenger Feed				2nd Scav Feed		Total		Nominal Res. Time			
	NaIX g/t	DF-250 g/t	Pulp pH	NaIX g/t	DF-250 g/t	Pulp pH	Temp deg C	NaIX g/t	DF-250 g/t	CuSO4 g/t	Pulp pH	NaIX g/t	DF-250 g/t	NaIX g/t	DF-250 g/t	Column min	P. Ro min	S. Ro min	Scav min
PP-24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PP-25	--	--	--	84.1	36.5	8.9	19.0	47.1	37.7	64.1	8.0	32.4	23.5	163.6	97.7	--	--	--	--
PP-26	30.6	15.6	--	--	--	9.1	15.5	49.4	12.3	45.7	8.0	34.0	12.3	157.4	65.4	1.9	4.0	1.4	8.9
PP-27	--	--	--	74.1	40.8	9.4	20.0	20.8	15.6	37.6	8.5	28.3	17.3	79.8	48.6	--	5.5	2.4	27.1
PP-28	--	--	--	39.4	23.4	11.5	23.0	24.6	12.3	35.1	11.3	34.5	20.9	98.5	56.6	--	3.7	1.3	7.7
PP-29	--	--	--	44.3	39.4	9.1	24.0	45.6	12.5	37.5	8.4	33.7	25.0	123.7	76.8	--	6.7	3.4	38.7
PP-30	--	--	--	45.4	41.0	9.3	24.0	43.5	11.8	38.5	8.6	33.0	25.5	121.9	78.3	--	6.5	3.2	38.3
PP-31	19.2	30.9	9.8	32.8	16.1	9.4	27.0	43.3	12.4	36.5	8.5	32.2	25.4	127.5	84.8	1.3	4.2	1.4	23.3
PP-32	17.7	29.3	8.5	29.9	17.7	8.0	28.0	42.1	11.6	36.6	7.6	29.9	24.4	119.7	83.0	3.0	5.1	2.8	35.6
PP-33	18.6	32.2	9.6	27.9	19.2	9.3	25.5	45.2	13.6	35.9	8.4	31.0	26.6	122.7	91.7	2.0	6.6	3.2	38.3
PP-34	--	--	--	47.0	45.8	9.3	26.0	43.3	11.6	37.8	8.6	31.1	23.8	121.4	81.2	--	4.1	2.5	32.8
PP-35	17.3	27.5	9.2	28.1	17.3	9.0	27.0	40.0	10.8	35.9	8.7	30.5	24.5	115.9	80.1	1.6	3.8	1.7	25.2
PP-36	18.8	30.8	9.8	32.0	18.2	9.4	24.7	44.0	11.9	38.9	8.4	31.4	25.7	126.2	86.7	2.5	13.6	1.8	44.1
PP-37	--	--	--	51.2	47.6	9.3	24.8	42.6	12.2	37.8	8.7	30.5	25.0	124.3	84.7	--	15.6	2.3	37.0
PP-38	18.3	31.5	9.5	32.1	17.6	8.8	24.0	44.1	12.6	40.3	8.6	31.5	25.2	126.0	86.9	2.5	10.4	2.6	40.2
PP-39	18.7	32.4	9.5	31.1	18.7	9.2	23.0	43.6	12.5	39.2	8.4	31.1	24.9	124.6	88.5	2.9	12.1	3.0	51.2
PP-40	18.1	31.1	9.4	31.1	18.1	9.1	24.0	44.2	12.5	37.4	8.8	29.9	25.5	123.3	87.2	3.1	16.7	2.3	42.4
PP-41	18.7	28.9	10.4	30.8	16.9	10.0	24.0	42.8	12.1	36.2	9.5	30.2	25.9	122.4	83.8	3.2	18.8	2.6	34.7
Avg	**19.6**	**29.0**	**9.5**	**41.3**	**27.1**	**9.3**	**23.7**	**41.5**	**13.9**	**39.5**	**8.6**	**31.5**	**23.6**	**123.5**	**80.1**	**2.4**	**8.6**	**2.4**	**32.8**
Max	30.6	32.4	10.4	84.1	47.6	11.5	28.0	49.4	37.7	64.1	11.3	34.5	26.6	163.6	97.7	3.2	18.8	3.4	51.2
Min	17.3	15.6	8.5	27.9	16.1	8.0	15.5	20.8	10.8	35.1	7.6	28.3	12.3	79.8	48.6	1.3	3.7	1.3	7.7
%S.D.	20%	17%	5%	40%	45%	7%	13%	18%	45%	17%	9%	5%	15%	15%	16%	28%	60%	29%	36%

Metallurgical Summary

Test	General Feed Conditions						Column	Column Concentrate			Prim. Rghr Concentrate			Final	Total Concentrates			Col + P.Rghr		
	% - 100 m	Dens % Sol	NaIX g/t	DF250 g/t	Assay % Ni	Assay % Cu	Feed kg/h	Mass Wt %	Assay % Ni	Rec'y Ni	Mass Wt %	Assay % Ni	Rec'y Ni	Tails % Ni	Mass Wt %	Assay % Ni	Rec'y Ni	Mass Wt %	Assay % Ni	Rec'y Ni
PP-24	75.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PP-25	79.0	21	163.6	97.7	1.51	0.66	--	--	--	--	18.9	5.13	64.2	0.41	27.6	4.59	83.8	18.9	5.13	64.2
PP-26	74.1	18	157.4	65.4	1.39	0.62	1,135	9.0	7.48	48.3	5.7	3.87	15.9	0.18	31.3	4.07	91.2	14.7	6.08	64.3
PP-27	79.8	27	79.8	48.6	1.36	0.61	--	--	--	--	3.8	8.87	24.8	0.26	28.5	4.14	86.5	3.8	8.87	24.8
PP-28	80.6	37	98.5	56.6	1.39	0.64	--	--	--	--	4.3	6.31	19.7	1.16	4.8	6.10	20.9	4.3	6.31	19.7
PP-29	78.5	30	123.7	76.8	1.46	0.68	--	--	--	--	11.7	6.49	51.8	0.22	39.7	3.35	90.9	11.7	6.49	51.8
PP-30	81.6	29	121.9	78.3	1.37	0.66	--	--	--	--	11.0	6.46	52.2	0.22	37.0	3.32	89.7	11.0	6.46	52.2
Avg	**78.4**	**27**	**124.2**	**78.6**	**1.41**	**0.65**	**1,135**	**9.0**	**7.5**	**48.3**	**9.2**	**6.19**	**38.1**	**0.41**	**28.2**	**4.26**	**77.2**	**10.7**	**6.56**	**46.2**
Max	81.6	37	163.6	97.7	1.51	0.68	--	--	--	--	18.9	8.87	64.2	1.16	39.7	6.10	91.2	18.9	8.87	64.3
Min	74.1	18	79.8	48.6	1.36	0.61	--	--	--	--	3.8	3.87	15.9	0.18	4.8	3.32	20.9	3.8	5.13	19.7
%SD	4%	25%	26%	25%	4%	4%	--	--	--	--	63%	27%	53%	92%	44%	24%	36%	55%	19%	42%
PP-31	78.4	20	127.5	84.8	1.55	0.62	1,519	6.8	5.60	24.7	6.3	4.64	18.9	0.51	29.0	4.10	76.7	13.1	5.14	43.5
PP-32	77.8	23	119.7	83.0	1.40	0.64	642.9	8.1	7.40	42.5	5.8	5.21	21.6	0.20	34.4	3.69	90.5	13.9	6.53	64.6
PP-33	70.8	20	122.7	91.7	1.39	0.58	961.5	2.4	5.21	8.9	9.4	4.23	28.8	0.27	36.5	3.33	87.6	11.8	4.43	37.7
PP-34	75.1	21	121.4	81.2	1.25	0.59	--	--	--	--	11.1	6.87	61.3	0.19	33.6	3.33	89.7	11.1	6.87	61.3
PP-35	68.4	19	115.9	80.1	1.24	0.60	1,096	7.6	6.96	42.6	6.7	5.07	27.6	0.15	32.0	3.54	91.6	14.3	6.06	70.0
PP-36	69.5	21	126.2	86.7	1.29	0.62	721.1	6.4	7.97	39.7	8.0	4.60	28.6	0.15	35.1	3.40	92.4	14.5	6.10	68.3
PP-37	87.2	20	124.3	84.7	1.24	0.63	--	--	--	--	14.3	5.83	67.1	0.13	33.0	3.49	92.9	14.3	5.83	67.1
PP-38	77.6	24	126.0	86.9	1.30	0.52	586.8	0.9	6.55	4.8	13.5	5.62	58.8	0.16	36.3	3.29	92.0	14.5	5.67	63.5
PP-39	73.5	22	124.6	88.5	1.33	0.63	572.0	2.3	7.59	13.4	11.9	5.89	52.5	0.15	36.8	3.35	92.8	14.2	6.17	65.8
PP-40	79.3	21	123.3	87.2	1.36	0.63	723.9	3.6	8.56	22.5	13.6	4.97	50.2	0.21	29.1	4.14	89.2	17.2	5.71	72.7
PP-41	82.0	21	122.4	83.8	1.43	0.60	792.4	7.9	6.56	36.1	9.1	5.31	33.6	0.21	34.7	3.74	90.3	17.0	5.86	69.4
Avg	**76.3**	**21**	**123.1**	**85.3**	**1.34**	**0.61**	**846.1**	**5.1**	**6.93**	**26.1**	**10.0**	**5.29**	**40.8**	**0.21**	**33.7**	**3.58**	**89.6**	**14.2**	**5.85**	**62.2**
Max	87.2	24	127.5	91.7	1.55	0.64	1,519	8.1	8.56	42.6	14.3	6.87	67.1	0.51	36.8	4.14	92.9	17.2	6.87	72.7
Min	68.4	19	115.9	80.1	1.24	0.52	572.0	0.90	5.21	4.80	5.80	4.23	18.9	0.13	29.00	3.29	76.7	11.10	4.43	37.7
%SD	7%	7%	3%	4%	7%	6%	36%	55%	16%	57%	31%	14%	43%	50%	8%	8%	5%	13%	11%	18%

Summary of Unit Performance

Test	Unit Column Cell					Primary Rougher					Secondary Rougher					Scavenger				
	Concentrate		Unit Recov		Ratio	Concentrate		Unit Recov		Ratio	Concentrate		Unit Recov		Ratio	Concentrate		Unit Recov		Ratio
	% Ni	% Pn	Ni	Pn	Po/Pn	% Ni	% Pn	Ni	Pn	Po/Pn	% Ni	% Pn	Ni	Pn	Po/Pn	% Ni	% Pn	Ni	Pn	Po/Pn
PP-24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
PP-25	–	–	–	–	–	5.13	12.8	65.4	–	–	3.41	–	44.5	95.0	–	–	–	–	–	–
PP-26	7.48	19.2	19.6	21.5	3.0	3.87	9.61	30.9	33.1	5.3	3.33	8.58	16.6	19.1	3.4	2.08	4.23	70.4	65.9	19.8
PP-27	–	–	–	–	–	8.87	22.9	24.8	25.8	1.9	9.50	25.0	21.6	23.3	1.5	2.77	6.57	77.2	76.6	9.1
PP-28	–	–	–	–	–	6.31	15.6	19.7	20.1	2.4	4.12	10.2	1.5	1.6	4.9	–	–	–	–	–
PP-29	–	–	–	–	–	6.49	16.5	51.8	53.8	3.4	3.99	9.84	7.3	7.8	6.0	1.95	4.39	79.5	77.0	12.4
PP-30	–	–	–	–	–	6.46	16.6	52.2	54.8	2.8	3.83	9.57	11.4	12.3	5.3	1.83	4.00	75.8	72.5	14.5
PP-31	5.60	14.0	7.0	7.6	4.1	4.64	11.7	25.1	25.5	4.5	4.37	11.1	7.7	7.9	4.4	3.12	7.22	55.4	52.3	10.6
PP-32	7.40	19.0	25.7	28.0	2.9	5.21	13.2	37.5	40.3	4.0	3.55	8.97	5.7	6.4	4.3	1.70	3.55	71.5	66.9	17.8
PP-33	5.21	12.9	3.4	3.6	3.9	4.23	10.5	31.6	32.1	5.0	4.78	12.1	8.0	8.4	4.2	2.68	6.31	78.4	76.7	9.6
PP-34	–	–	–	–	–	6.87	17.8	61.3	64.6	2.6	3.96	10.0	2.6	3.0	4.3	1.54	3.21	72.6	68.1	17.8
PP-35	6.96	18.0	17.7	20.2	2.4	5.07	12.9	47.9	52.2	3.9	3.35	8.19	4.2	4.8	6.5	1.46	2.83	70.8	64.6	23.4
PP-36	7.97	20.5	22.0	24.0	2.6	4.60	11.6	47.4	51.0	4.6	2.97	7.12	4.9	5.4	7.9	1.46	2.95	74.8	69.9	20.3
PP-37	–	–	–	–	–	5.83	14.9	67.1	70.3	3.0	3.33	8.29	3.6	4.0	5.4	1.65	3.45	77.4	73.7	17.7
PP-38	6.55	16.5	2.8	3.0	3.0	5.62	14.5	61.7	65.2	3.1	3.63	9.09	1.7	1.9	4.7	1.68	3.54	77.8	74.1	17.1
PP-39	7.59	19.2	8.3	8.9	2.0	5.89	15.2	60.5	64.6	3.2	3.06	7.61	1.8	2.1	5.4	1.57	3.22	78.6	74.6	19.3
PP-40	8.56	21.7	11.8	12.6	3.0	4.97	12.4	64.8	64.7	5.3	3.52	9.03	10.8	11.1	3.7	1.82	4.38	59.5	57.8	7.9
PP-41	6.56	16.6	18.8	20.4	3.7	5.31	13.4	52.6	54.0	4.4	3.69	9.31	6.3	6.6	4.6	1.61	3.70	66.3	63.6	11.1
Avg	6.99	17.7	13.7	15.8	3.06	5.61	14.2	47.2	48.3	3.71	4.02	10.3	9.42	13.8	4.78	1.93	4.24	72.4	69.8	15.2
Max	8.56	21.7	25.7	28.0	4.10	8.87	22.9	67.1	70.3	5.30	9.50	25.0	44.5	95.0	7.90	3.12	7.22	79.5	77.0	23.4
Min	5.21	12.9	2.80	3.00	2.00	3.87	9.61	19.7	20.1	1.90	2.97	7.12	1.50	1.60	1.50	1.46	2.83	55.4	52.3	7.90
%S.D.	15%	16%	59%	60%	22%	21%	22%	34%	34%	29%	37%	40%	112%	169%	30%	27%	32%	10%	11%	32%

Summary of Unit Column, Primary Rougher and Combined Concentrates

Test	Unit Column Cell								Primary Rougher								Combined Concentrate						
	F80	Mass	Grade		Recovery		Ratio	P80	F80	Mass	Grade		Recovery		Ratio	P80	Mass	Grade		Recovery		Ratio	P80
	µm	Wt%	%Ni	%Pn	Ni	Pn	Po/Pn	µm	µm	Wt%	%Ni	%Pn	Ni	Pn	Po/Pn	µm	Wt%	%Ni	%Pn	Ni	Pn	Po/Pn	µm
24	--	--	--	--	--	--	--	--	165	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25	--	--	--	--	--	--	--	--	151	18.9	5.13	12.8	64.2	65.4	4.9	86	27.6	4.59	3.70	83.8	84.9	5.5	79
26	781	9.0	7.48	19.2	48.3	50.9	3.0	122	169	5.7	3.87	9.61	15.9	16.2	5.3	70	31.3	4.07	9.89	91.2	90.9	6.6	129
27	--	--	--	--	--	--	--	--	148	3.8	8.87	22.9	24.8	25.8	1.9	71	28.5	4.14	10.3	86.5	86.7	5.4	125
28	--	--	--	--	--	--	--	--	145	4.3	6.31	15.6	19.7	20.1	2.4	83	4.8	6.10	15.2	20.9	21.3	2.5	78
29	--	--	--	--	--	--	--	--	153	11.7	6.49	16.5	51.8	53.8	3.4	90	39.7	3.35	8.13	90.9	90.2	6.8	161
30	--	--	--	--	--	--	--	--	140	11.0	6.46	16.6	52.2	54.8	2.8	95	37.0	3.32	8.04	89.7	89.1	6.7	169
31	656	6.8	5.60	14.0	24.7	24.8	4.1	90	153	6.3	4.64	11.7	18.9	19.2	4.5	159	29.0	4.10	9.98	76.7	75.4	6.5	--
32	650	8.1	7.40	19.0	42.5	44.6	2.9	86	155	5.8	5.21	13.2	21.6	22.3	4.0	105	34.4	3.69	8.99	90.5	90.0	6.6	--
33	746	2.4	5.21	12.9	8.9	9.0	3.9	90	181	9.4	4.23	10.5	28.8	29.2	5.0	181	36.5	3.33	8.05	87.6	93.8	7.1	--
34	--	--	--	--	--	--	--	--	166	11.1	6.87	17.8	61.3	64.6	2.6	113	33.6	3.33	8.10	89.7	93.7	6.6	--
35	896	7.6	6.96	18.0	42.6	45.1	2.4	105	192	6.7	5.07	12.9	27.6	28.7	3.9	166	32.0	3.54	8.59	91.6	91.2	6.7	--
36	868	6.4	7.97	20.5	39.7	42.0	2.6	102	185	8.0	4.60	11.6	28.6	29.6	4.6	164	35.1	3.40	8.22	92.4	91.9	6.9	--
37	--	--	--	--	--	--	--	--	110	14.3	5.83	14.9	67.1	70.3	3.0	124	33.0	3.49	8.51	92.9	92.6	6.4	--
38	754	0.9	6.55	16.5	4.8	4.9	3.0	88	156	13.5	5.62	14.5	58.8	62.0	3.1	119	36.3	3.29	7.99	92.0	91.6	6.8	--
39	668	2.3	7.59	19.2	13.4	13.9	2.0	88	173	11.9	5.89	15.2	52.5	55.7	3.2	105	36.8	3.35	8.11	92.8	92.4	6.9	--
40	705	3.6	8.56	21.7	22.5	22.8	3.0	109	150	13.6	4.97	12.4	50.2	50.0	5.3	132	29.1	4.14	10.3	89.2	88.7	5.1	--
41	753	7.9	6.56	16.6	36.1	36.8	3.7	79	138	9.1	5.31	13.4	33.6	34.2	4.4	123	34.7	3.74	9.27	90.3	90.0	5.5	--
Avg	**744**	**5.1**	**6.93**	**17.6**	**26.1**	**27.1**	**3.1**	**93**	**160**	**10.0**	**5.29**	**13.5**	**40.8**	**42.3**	**4.0**	**136**	**34**	**3.58**	**8.74**	**89.6**	**90.1**	**6.46**	
Max	896	8.1	7.97	20.5	42.6	45.1	4.1	105	192	14.3	6.87	17.8	67.1	70.3	5.0	181	37	4.10	9.98	92.9	93.8	7.10	
Min	650	0.9	5.21	12.9	4.8	4.9	2.4	86	110	5.8	4.23	10.5	18.9	19.2	2.6	105	29	3.29	7.99	76.7	75.4	6.40	
%SD	11%	57%	15%	16%	60%	61%	22%	14%	12%	41%	22%	23%	44%	44%	27%	25%	23%	20%	25%	19%	19%	17%	

Summary of Column Flotation (Wash constant at 1.33 L/min. Bias constant at 0.13 cm/s)

Test	Feed Conditions				Operating Conditions									Tails			Concentrate			
	CLR %	Solids tph	Pulp L/min	K80 µm	Level cm	Volume L	NRT min	Holdup %	Gas L/min	Gas cm/s	Tails cm/s	Conc kg/h	Loading g/min/cm2	Pulp L/min	Density		P80 µm	Grade %Ni	Grade %Pn	Recov Ni%
															g/L	%Sol				
PP-26	484	1,135	13.5	781	26.7	37.9	3.1	33.8	6.97	0.66	1.15	17.5	1.65	12.2	1,435	47.6	122	7.48	19.2	48.3
PP-31	683	1,519	14.7	656	25.0	38.2	2.8	42.6	10.7	1.01	1.26	13.2	1.24	13.4	1,580	57.7	90	5.60	14.0	24.7
PP-32	227	642.9	14.1	650	44.0	34.8	2.7	35.9	8.09	0.76	1.21	15.9	1.50	12.8	1,550	55.8	86	7.40	19.0	42.5
PP-33	397	961.5	14.8	746	37.0	36.0	2.7	33.3	9.46	0.89	1.27	4.6	0.43	13.5	1,503	52.6	90	5.21	12.9	8.9
PP-35	511	1,096	17.3	896	46.0	34.5	2.2	42.3	9.17	0.86	1.51	15.2	1.43	16.0	1,605	59.2	105	6.96	18.0	42.6
PP-36	277	721.1	14.2	868	50.0	33.7	2.6	32.2	6.72	0.63	1.22	12.3	1.16	12.9	1,512	53.2	102	7.97	20.5	39.7
PP-38	208	586.8	14.6	754	46.0	34.5	2.6	28.6	6.96	0.66	1.25	1.8	0.17	13.3	1,407	45.5	88	6.55	16.5	4.8
PP-39	197	572.0	13.1	668	48.0	34.1	2.9	29.4	8.57	0.81	1.11	4.5	0.42	11.8	1,500	52.4	88	7.59	19.2	13.4
PP-40	287	723.9	16.4	705	46.0	34.5	2.3	39.1	9.69	0.91	1.42	6.9	0.65	15.1	1,650	61.9	109	8.56	21.7	22.8
PP-41	298	792.4	13.0	753	46.0	34.5	2.9	40.0	10.7	1.01	1.10	15.7	1.48	11.7	1,667	62.9	79	6.56	16.6	36.1
Avg	**357**	**875.1**	**14.6**	**748**	**41.5**	**35.3**	**2.7**	**35.7**	**8.7**	**0.82**	**1.25**	**10.8**	**1.01**	**13.3**	**1,541**	**54.9**	**96**	**6.99**	**17.8**	**28.4**
Max	683	1,519	17.3	896	50.0	38.2	3.1	42.6	10.7	1.01	1.51	17.5	1.65	16.0	1,667	62.9	122	8.56	21.7	48.3
Min	197	572.0	13.0	650	25.0	33.7	2.2	28.6	6.7	0.63	1.10	1.8	0.17	11.7	1,407	45.5	79	5.21	12.9	4.8
%SD	45%	35%	9%	11%	21%	4%	11%	14%	17%	17%	10%	53%	53%	10%	6%	10%	14%	15%	16%	55%

1. Purpose: Preliminary run to fill the circuit and set up reagents.

2. Procedure: All process units started. Reagents were adjusted to levels used in a previous pilot plant run conducted at Lakefield Research on a sample of Strathcona ore.

2.1. Flowsheet: The flowsheet is shown in Figure 1b.

2.2. Equipment: The equipment list is shown in Table 1b.

3. Results:

Flotation Feed Size	75.2 % -100 mesh
Head Grades	1.51 % Ni 0.66 % Cu 24.5 % Fe 11.5 % S(T)

Although the flotation section was started, the shift was spent adjusting reagent and aeration rates, as well as launder sprays, etc., and no attempt was made to sample the flotation circuit.

The primary purpose of the run was to establish grinding circuit operation - this was accomplished. The screen analysis data included in this report indicate that the use of a nominal 60 mesh Kason sieve with an aperture of 234 μm yielded a screen undersize (flotation feed) product that was nearly identical to the size analysis currently in use at the Strathcona mill.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed: 193.8 kg/h of -1/4 inch feed. (Wet Sple 1136.3 g)
(Dry Sple 1114.3 g)
Feed Rate: 190.0 kg/h of dry ore. (Moisture 1.94 %)
Mill Speed: 45 RPM (85% of critical speed)
Rod Charge: 160 kg
Rod Mill Feed: Total 484 kg in 2.50 hr
Rod Mill Discharge: 1,660 g/L (56 % Sol at Solid SG of 3.40)
46.5 % plus 48 mesh
40.2 % minus 100 mesh
Input Power: 35.80 for 3 disc revolutions
1.09 kW (95% drive efficiency)
Average Power: 1.03 kW Gross
0.47 kW No Load
0.56 kW Net
Net Power Usage: 2.93 kWh/tonne of -1/4 inch feed.
K80 Feed: 3,325 microns
K80 Product: 861 microns
Work Index (metric): 17.5

3.1.2. Ball Mill Report:

Feed: Screen Oversize (at 468 % circ. load)
Feed Rate: 889.4 kg/h
Mill Speed: 40 RPM (77% of critical speed)
Ball Charge: 100 kg
Screen Undersize: 1,170 g/L (21 % Sol at S' 3.40)
Ball Mill Discharge: 74.1 % plus 48 mesh
13.2 % minus 100 mesh
Input Power: 5.00 for 3 disc revolutions
7.78 kW (95% drive efficiency)
Average Power: 7.39 kW Gross
0.52 kW No Load
6.86 kW Net
Net Power Usage: 7.72 kWh/tonne of screen oversize.
K80 Feed: 861 microns
K80 Product: 165 microns
Work Index (metric): 17.6

3.1.3. Overall Mill Report:

Net Power Usage:	10.65 kWh/t
K80 Feed:	3,325 microns
K80 Product:	165 microns
Work Index (metric):	17.6
Screen Undersize:	75.2 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	3,325	38.7
Rod Mill Discharge	861	40.2
Screen Feed		
Ball Mill Feed	1,456	5.5
Ball Mill Discharge	1,438	13.2
Screen Undersize	165	75.2

4. Metallurgical Results:

No samples taken.

5. Screen Analyses:

Detailed in the following pages.

Test No. PP-24 LR-3897

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
1/2"	1,330	0.0	0.0	0.0	100.0
3/8"	9,423	0.0	0.0	0.0	100.0
3	6,680	2.2	0.5	0.5	99.5
4	4,699	91.4	20.0	20.5	79.5
6	3,327	65.6	14.4	14.4	85.6
8	2,362	45.1	9.9	24.2	75.8
10	1,651	42.4	9.3	33.5	66.5
14	1,168	28.6	6.3	39.8	60.2
20	833	20.9	4.6	44.3	55.7
28	589	19.4	4.2	48.6	51.4
35	417	17.0	3.7	52.3	47.7
48	295	14.1	3.1	55.4	44.6
65	208	13.5	3.0	58.3	41.7
100	147	13.4	2.9	61.3	38.7
150	104	11.6	2.5	63.8	36.2
200	74	11.3	2.5	66.3	33.7
270	53	13.3	2.9	69.2	30.8
400	37	6.5	1.4	70.6	29.4
Pan	-37	42.9	9.4	80.0	20.0
Total	-	**456.9**	**100.5**	-	-
K80	**3,325**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	0.6	0.2	0.2	99.8
6	3,327	0.5	0.1	0.3	99.7
8	2,362	3.2	0.9	1.2	98.8
10	1,651	10.2	2.7	3.9	96.1
14	1,168	27.6	7.4	11.3	88.7
20	833	35.1	9.4	20.7	79.3
28	589	37.0	9.9	30.6	69.4
35	417	32.7	8.8	39.4	60.6
48	295	26.6	7.1	46.5	53.5
65	208	23.7	6.4	52.9	47.1
100	147	25.6	6.9	59.8	40.2
150	104	21.7	5.8	65.6	34.4
200	74	20.6	5.5	71.1	28.9
270	53	19.8	5.3	76.4	23.6
400	37	14.8	4.0	80.4	19.6
Pan	-37	73.1	19.6	100.0	0.0
Total	-	**372.8**	**100.0**	-	-
K80	**861**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	0.0	0.0	0.0	100.0
6	3,327	0.0	0.0	0.0	100.0
8	2,362	0.0	0.0	0.0	100.0
10	1,651	66.2	14.9	14.9	85.1
14	1,168	56.0	12.6	27.6	72.4
20	833	55.8	12.6	40.1	59.9
28	589	55.5	12.5	52.7	47.3
35	417	51.4	11.6	64.3	35.7
48	295	43.7	9.9	74.1	25.9
65	208	35.3	8.0	82.1	17.9
100	147	21.1	4.8	86.8	13.2
150	104	11.9	2.7	89.5	10.5
200	74	8.7	2.0	91.5	8.5
270	53	6.5	1.5	92.9	7.1
400	37	4.7	1.1	94.0	6.0
Pan	-37	26.6	6.0	100.0	0.0
Total	-	**443.4**	**100.0**	-	-
K80	**1,438**				

Screen Oversize (Ball Mill Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	0.0	0.0	0.0	100.0
6	3,327	0.0	0.0	0.0	100.0
8	2,362	0.0	0.0	0.0	100.0
10	1,651	59.2	14.8	14.8	85.2
14	1,168	57.2	14.3	29.1	70.9
20	833	57.1	14.3	43.4	56.6
28	589	59.2	14.8	58.2	41.8
35	417	54.7	13.7	71.9	28.1
48	295	46.0	11.5	83.4	16.6
65	208	30.8	7.7	91.1	8.9
100	147	13.3	3.3	94.5	5.5
150	104	6.2	1.6	96.0	4.0
200	74	3.7	0.9	96.9	3.1
270	53	2.3	0.6	97.5	2.5
400	37	1.5	0.4	97.9	2.1
Pan	-37	8.4	2.1	100.0	0.0
Total	-	**399.6**	**100.0**	-	-
K80	**1,456**				

Screen Undersize (Flotation Feed)

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	0.0	0.0	0.0	100.0
6	3,327	0.0	0.0	0.0	100.0
8	2,362	0.0	0.0	0.0	100.0
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.0	0.0	0.0	100.0
20	833	0.0	0.0	0.0	100.0
28	589	0.2	0.1	0.1	99.9
35	417	0.3	0.2	0.3	99.7
48	295	3.4	2.0	2.3	97.7
65	208	13.1	7.6	9.8	90.2
100	147	25.8	14.9	24.8	75.2
150	104	21.9	12.7	37.5	62.5
200	74	19.3	11.2	48.6	51.4
270	53	16.5	9.6	58.2	41.8
400	37	12.8	7.4	65.6	34.4
Pan	-37	59.4	34.4	100.0	0.0
Total	-	**172.7**	**100.0**	-	-
K80	**165**				

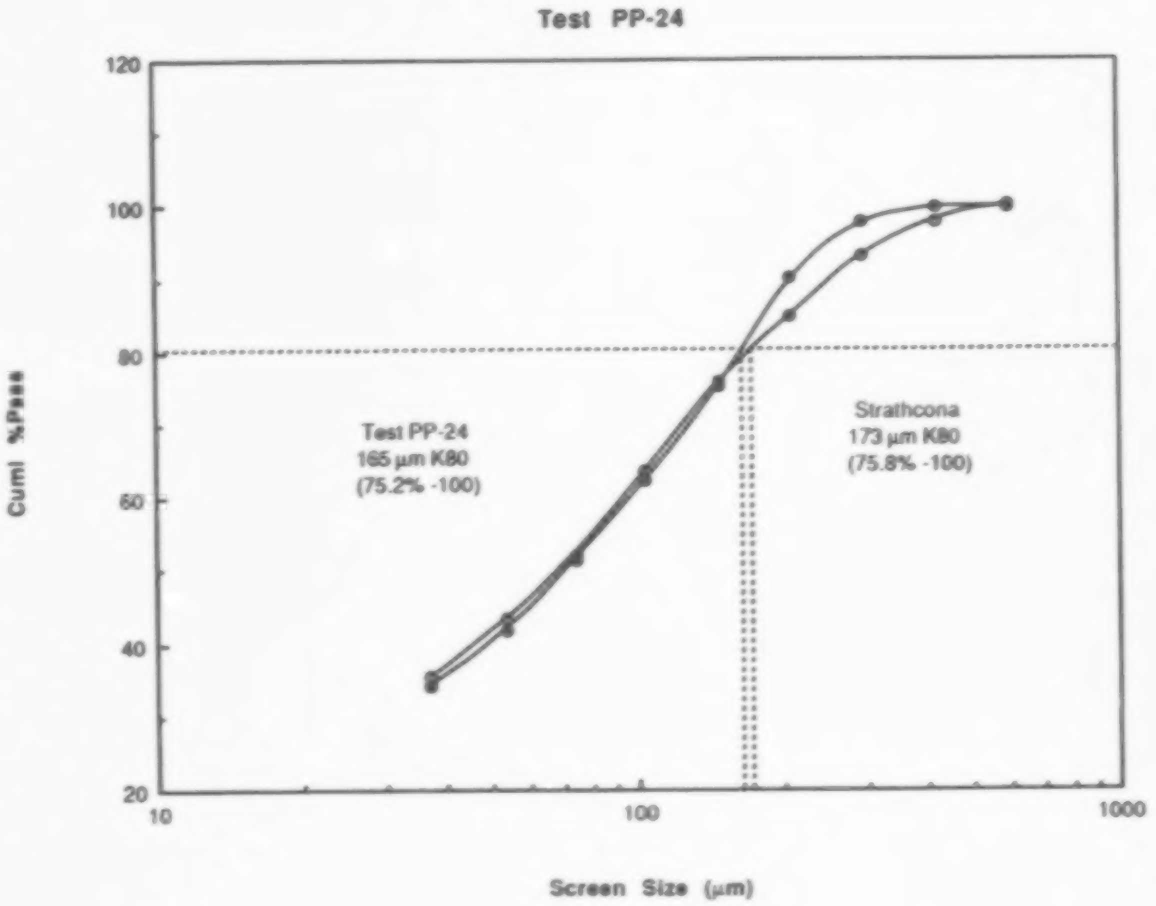
Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data

(based on 60 mesh Kason screen with 234 µm aperture)

C L R
468%

Size	Individual and Cumulative % on Fraction			
(mesh)	RMD	BMD	SOS	SUS
+48	46.5	74.1	83.4	0.0
-48+100	13.2	12.7	11.0	22.5
-100+200	11.3	4.6	2.5	23.9
-200+400	9.3	2.5	1.0	17.0
-400	19.6	6.0	2.1	36.7
Total	100.0	100.0	100.0	100.0

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	499 %	69.5	347 %
-48+100	552 %	12.8	71 %
-100+200	577 %	5.6	33 %
-200+400	488 %	3.7	18 %
-400	437 %	8.4	37 %
Total		100.0	**468 %**


Test PP-24
Cuml %Pass
120
100
80
60
40
20
10
100
1000
Screen Size (µm)
Test PP-24
165 µm K80
(75.2% -100)
Strathcona
173 µm K80
(75.8% -100)

1. Purpose: Preliminary run to fill the circuit and set up reagents.

2. Procedure: All process units started. Reagents were adjusted to levels used in a previous pilot plant run conducted at Lakefield Research on a sample of Strathcona ore.

2.1. Flowsheet: The flowsheet is shown in Figure 1b.

2.2. Equipment: The equipment list is shown in Table 1b.

3. Results:

Flotation Feed Size		79% -100 m	
		Ni	Cu
Head Grades		1.51	0.66
Primary Rougher	Grade	5.13	3.00
	Recov	64.2	85.5
Secondary Rougher	Grade	3.41	0.72
	Recov	19.6	9.5
Overall Circuit	Grade	4.59	2.28
	Recov	83.8	95.0

The scavenger circuit was started, but there was insufficient time during the test run for this part of the circuit to fill and to achieve stable operation. For this reason, the scavenger circuit was not sampled. Circuit sampling consisted of a composite of two grab samples taken near the end of the production period.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	205.3 kg/h of -1/4 inch feed (Wet Sple 366.0 g)
	(Dry Sple 363.6 g)
Feed Rate:	204.0 kg/h of dry ore. (Moisture 0.66 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 513 kg in 2.50 hr
	Sample 103 kg in 0.50 hr
Rod Mill Discharge:	1,690 g/L (58 % Sol at Solid SG of 3.40)
	44.5 % plus 48 mesh
	40.5 % minus 100 mesh
Input Power:	37.22 for 3 disc revolutions
	1.04 kW (95% drive efficiency)
Average Power:	0.99 kW Gross
	0.47 kW No Load
	0.52 kW Net
Net Power Usage:	2.54 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,529 microns
K80 Product:	714 microns
Work Index (metric):	11.3

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 615 % circ. load)
Feed Rate:	1,254.4 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,170 g/L (21 % Sol at S 3.40)
Ball Mill Discharge:	2,053 g/L (73 % Sol at S 3.40)
	74.9 % plus 48 mesh
	12.8 % minus 100 mesh

3.1.3. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,529	15.9
Rod Mill Discharge	714	40.5
Screen Feed		
Ball Mill Feed	1,306	5.5
Ball Mill Discharge	1,334	12.8
Screen Undersize	151	79.0
Prim Rghr Conc	86.1	90.7
Sec'ry Rghr Conc	64.1	94.8
Final Tailing	156	78.0

3.2. Reagent Additions:

Average Feed Rate: 0.204 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	NaIX	2.0%	14.3	84.1
	DF-250	2.0%	6.2	36.5
Scavenger 1 Feed	NaIX	2.0%	8.0	47.1
	DF-250	2.0%	6.4	37.7
	CuSO4	2.0%	10.9	64.1
Scavenger 2 Feed	NaIX	2.0%	5.5	32.4
	DF-250	2.0%	4.0	23.5
Total	**NaIX**		27.8	**163.6**
	DF-250		16.6	**97.7**
	CuSO4		10.9	**64.1**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,690			3.40
Ball Mill Discharge	2,053			
Screen Feed	1,690			
Screen Undersize	1,170			
Rougher Feed		8.9	19.0	
Scavenger 1 Feed	1,093	8.0		

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio From screens 615% BILCO 615%

Product	Direct Assays			Adjusted Assays			Mass
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h
Rod Mill Feed	1.41	0.59	11.1	1.51	0.66	11.4	204.0
Rod Mill Discharge	1.54	0.67	11.8	1.51	0.66	11.4	204.0
Ball Mill Discharge	0.59	0.40	6.28	0.59	0.41	6.32	1,254.4
Screen Feed (calc)	0.72	0.44	7.05	0.72	0.44	7.07	1,458.4
Screen Oversize	0.58	0.41	6.35	0.59	0.41	6.32	1,254.4
Screen Undersize	1.88	0.77	12.8	1.51	0.66	11.4	204.0
Prim Rghr Conc	4.99	3.37	30.6	5.13	3.00	32.3	38.6
Prim Rghr Tail	0.66	0.10	7.98	0.67	0.12	6.48	165.4
Sec Rghr Conc	3.38	0.84	26.5	3.41	0.72	28.6	17.8
Sec Rghr Tail	0.41	0.071	3.96	0.41	0.061	4.36	147.6

4.2. Metallurgical Balance:

Product	Overall Wt %	Metal Assays			Distributions (%)		
		% Ni	% Cu	% S(T)	Ni	Cu	S(T)
Prim Rghr Feed	100.0	1.51	0.66	11.4	100.0	100.0	100.0
Prim Rghr Conc	18.9	5.13	3.00	32.3	64.2	85.5	53.8
Prim Rghr Tail	81.1	0.67	0.12	6.48	35.8	14.6	46.2
Sec Rghr Feed	81.1	0.67	0.12	6.48	35.8	14.6	46.2
Sec Rghr Conc	8.7	3.41	0.72	28.6	19.6	9.5	22.0
Sec Rghr Tail	72.4	0.41	0.06	4.36	19.5	6.7	27.8
Comb Rghr Feed	100.0	1.51	0.66	11.4	100.0	100.0	100.0
Comb Rghr Conc	27.6	4.59	2.28	31.2	83.8	95.0	75.8
Comb Rghr Tail	72.4	0.41	0.06	4.36	19.5	6.7	27.8

4.3. Mineralogical Balance:

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Mineral Assays			Distributions (%)		
		% Pn	% Po	% Cp	Pn	Po	Cp
Prim Rghr Feed	100.0	3.70	23.8	1.92	100.0	100.0	100
Prim Rghr Conc	18.9	12.8	62.7	8.69	65.4	49.9	85.5
Prim Rghr Tail	81.1	1.58	14.7	0.35	34.6	50.1	14.5
Sec Rghr Feed	81.1	1.58	14.7	0.35	34.6	50.1	14.5
Sec Rghr Conc	8.7	8.23	63.3	2.09	19.4	23.2	9.5
Sec Rghr Tail	72.4	0.94	10.0	0.18	15.1	26.8	5.0
Comb Rghr Feed	100.0	3.70	23.8	1.92	100.0	100.0	100.0
Comb Rghr Conc	27.6	11.3	62.9	6.61	84.9	73.2	95.0
Comb Rghr Tail	72.4	0.94	10.0	0.18	18.4	30.5	6.7

4.4. Individual Unit Performance: (applies equally to metals and minerals)

Product	Individual Wt %	Assays			Distributions (%)		
		% Ni	% Cu	% S(T)	Ni (Pn)	Cu (Po)	S(T) (Cp)
Prim Rghr Feed	100.0	1.51	0.66	11.4	100.0	100.0	100.0
Prim Rghr Conc	18.9	5.13	3.00	32.3	65.4	49.9	85.5
Prim Rghr Tail	81.1	0.67	0.12	6.48	34.6	50.1	14.5
Sec Rghr Feed	100.0	0.67	0.12	6.48	100.0	100.0	100.0
Sec Rghr Conc	8.7	3.41	0.72	28.6	44.5	52.7	38.5
Sec Rghr Tail	91.3	0.41	0.06	4.36	55.5	47.3	61.5

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	58.7	18.2	18.2	81.8
6	3,327	48.0	14.9	33.2	66.8
8	2,362	38.1	11.8	45.0	55.0
10	1,651	40.5	12.6	57.6	42.4
14	1,168	22.9	7.1	64.7	35.3
20	833	15.9	4.9	69.6	30.4
28	589	13.1	4.1	73.7	26.3
35	417	10.6	3.3	77.0	23.0
48	295	7.9	2.5	79.5	20.5
65	208	7.5	2.3	81.8	18.2
100	147	7.4	2.3	84.1	15.9
150	104	6.7	2.1	86.2	13.8
200	74	6.6	2.1	88.2	11.8
270	53	6.4	2.0	90.2	9.8
400	37	4.8	1.5	91.7	8.3
Pan	-37	26.7	8.3	100.0	-
Total	-	**321.8**	**100.0**	-	-
K80	**4,529**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.1	2.1	2.1	97.9
14	1,168	9.7	4.9	7.0	93.0
20	833	15.8	8.0	15.0	85.0
28	589	20.8	10.6	25.6	74.4
35	417	20.6	10.5	36.0	64.0
48	295	16.6	8.4	44.5	55.5
65	208	14.1	7.2	51.6	48.4
100	147	15.6	7.9	59.5	40.5
150	104	13.0	6.6	66.1	33.9
200	74	11.6	5.9	72.0	28.0
270	53	11.6	5.9	77.9	22.1
400	37	8.8	4.5	82.4	17.6
Pan	-37	34.7	17.6	100.0	-
Total	-	**197.0**	**100.0**	-	-
K80	**714**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	26.3	10.5	10.5	89.5
14	1,168	34.4	13.8	24.3	75.7
20	833	39.4	15.8	40.1	59.9
28	589	40.4	16.2	56.3	43.7
35	417	36.3	14.6	70.9	29.1
48	295	29.7	11.9	82.8	17.2
65	208	20.6	8.3	91.1	8.9
100	147	8.5	3.4	94.5	5.5
150	104	4.0	1.6	96.1	3.9
200	74	2.4	1.0	97.0	3.0
270	53	1.6	0.6	97.7	2.3
400	37	1.0	0.4	98.1	1.9
Pan	-37	4.8	1.9	100.0	-
Total	-	**249.4**	**100.0**	-	-
K80	**1,306**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	17.8	11.6	11.6	88.4
14	1,168	20.9	13.6	25.1	74.9
20	833	21.6	14.0	39.2	60.8
28	589	21.2	13.8	52.9	47.1
35	417	18.7	12.1	65.1	34.9
48	295	15.2	9.9	74.9	25.1
65	208	11.8	7.7	82.6	17.4
100	147	7.1	4.6	87.2	12.8
150	104	4.0	2.6	89.8	10.2
200	74	2.9	1.9	91.7	8.3
270	53	2.4	1.6	93.2	6.8
400	37	1.9	1.2	94.5	5.5
Pan	-37	8.5	5.5	100.0	-
Total	-	**154.0**	**100.0**	-	-
K80	**1,334**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	8.9	8.6	8.6	91.4
100	147	12.8	12.4	21.0	79.0
150	104	11.9	11.5	32.5	67.5
200	74	11.4	11.0	43.6	56.4
270	53	10.1	9.8	53.3	46.7
400	37	9.0	8.7	62.1	37.9
Pan	-37	39.2	37.9	100.0	-
Total	-	**103.3**	**100.0**	-	-
K80	**151.1**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.0	3.1	3.1	96.9
100	147	2.0	6.2	9.3	90.7
150	104	2.1	6.5	15.8	84.2
200	74	2.4	7.5	23.3	76.7
270	53	2.9	9.0	32.3	67.7
400	37	3.2	9.9	42.2	57.8
Pan	-37	18.6	57.8	100.0	-
Total	-	**32.2**	**100.0**	-	-
K80	**86.1**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.2	1.3	1.3	98.7
100	147	0.6	3.9	5.2	94.8
150	104	0.7	4.5	9.7	90.3
200	74	1.0	6.5	16.1	83.9
270	53	1.4	9.0	25.2	74.8
400	37	1.5	9.7	34.8	65.2
Pan	-37	10.1	65.2	100.0	-
Total	-	**15.5**	**100.0**	-	-
K80	**64.1**				

Secondary Rougher Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	7.2	8.6	8.6	91.4
100	147	11.1	13.3	22.0	78.0
150	104	9.7	11.6	33.6	66.4
200	74	8.4	10.1	43.7	56.3
270	53	8.2	9.8	53.5	46.5
400	37	6.5	7.8	61.3	38.7
Pan	-37	32.2	38.7	100.0	-
Total	-	**83.3**	**100.0**	-	-
K80	**155.5**				

Calculation of Circulating Load Ratio (CLR) Using Grouped Screen Analysis Data

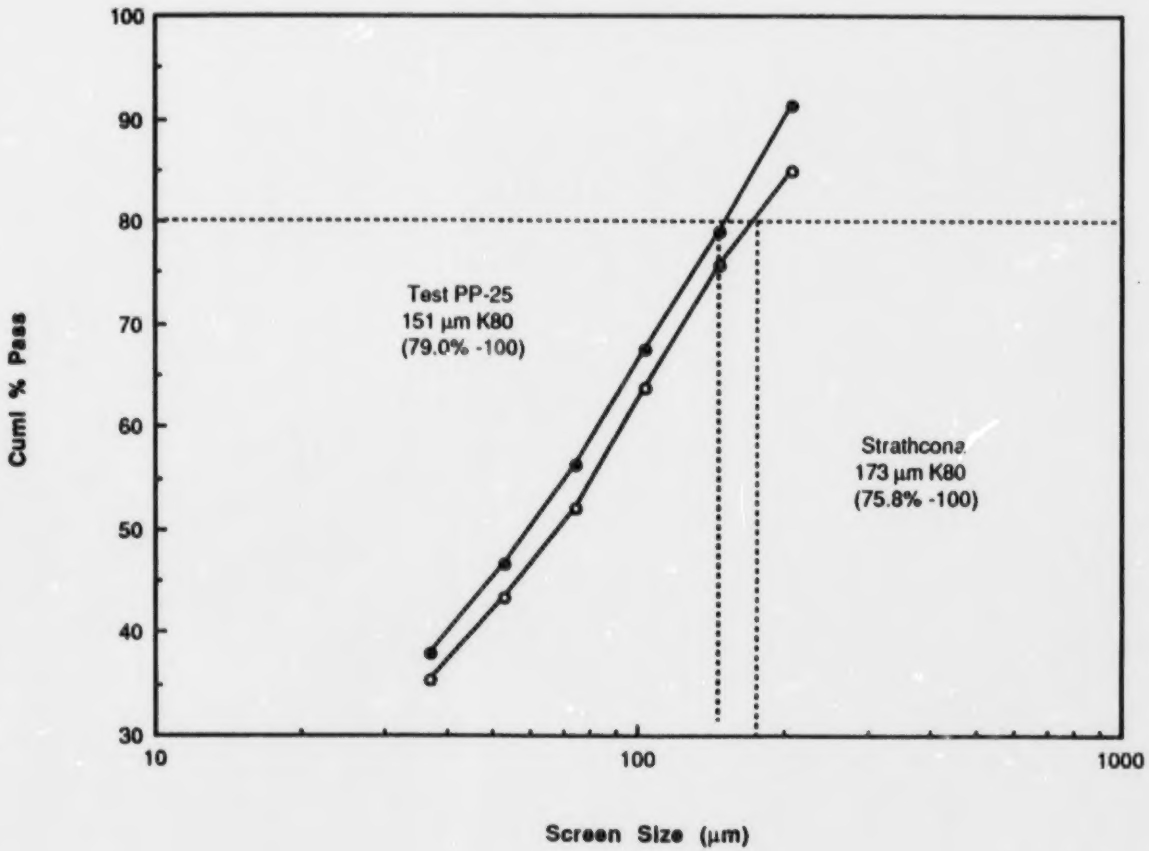
(based on 60 mesh Kason screen with 234 µm aperture)

C L R
570%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	44.5	74.9	82.8	0.0
-48+100	15.1	12.3	11.7	21.0
-100+200	12.5	4.5	2.6	22.6
-200+400	10.4	2.8	1.0	18.5
-400	17.6	5.5	1.9	37.9

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	565 %	70.4	398 %
-48+100	981 %	12.5	123 %
-100+200	526 %	5.8	30 %
-200+400	465 %	4.1	19 %
-400	566 %	7.2	41 %
Total		100.0	**570 %**

Test PP-25


Cuml % Pass
100
90
80
70
60
50
40
30
10
100
1000
Screen Size (µm)
Test PP-25
151 µm K80
(79.0% -100)
Strathcona
173 µm K80
(75.8% -100)

1. Purpose: First Unit Column Cell run - preliminary.

2. Procedure: All process units started, including unit column.

2.1. Flowsheet: The flowsheet is shown in Figure 1b.

2.2. Equipment: The equipment list is shown in Table 1b.

3. Results:

Flotation Feed Size		74.1 % -100 mesh			169 μm K80	
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.39	0.62	3.40	1.80	6.50
Unit Column	Grade	7.48	4.43	19.2	12.8	2.96
	Recov	48.3	64.3	50.9	64.3	1.37
Primary Rougher	Grade	3.87	2.03	9.61	5.88	5.30
	Recov	15.9	18.8	16.2	18.8	2.65
Secondary Rougher	Grade	3.33	1.12	8.58	3.25	3.42
	Recov	5.9	4.5	6.3	4.5	2.01
Scavenger	Grade	2.08	0.30	4.23	0.87	19.8
	Recov	20.9	6.8	17.5	6.8	2.16
Overall Circuit	Grade	4.07	1.87	9.89	5.43	6.64
	Recov	91.2	94.5	90.9	94.5	8.19

The unit column produced a higher grade concentrate, and resulted in a lower grade concentrate being pulled in the primary rougher. This was an expected result.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	197.3 kg/h of -1/4 inch feed (Wet Sple 448.8 g)
	(Dry Sple 442.1 g)
Feed Rate:	194.4 kg/h of dry ore. (Moisture 1.49 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 1,036 kg in 5.25 hr
	Sample 197 kg in 1.00 hr
Rod Mill Discharge:	1,600 g/L (53 % Sol at Solid SG of 3.42)
	47.4 % plus 48 mesh
	37.3 % minus 100 mesh
Input Power:	35.18 for 3 disc revolutions
	1.11 kW (95% drive efficiency)
Average Power:	1.05 kW Gross
	0.47 kW No Load
	0.58 kW Net
Net Power Usage:	2.96 kWh/tonne of -1/4 inch feed.
K80 Feed:	3,221 microns
K80 Product:	738 microns
Work Index (metric):	15.4

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 484 % circ. load)
Feed Rate:	940.7 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,150 g/L (18 % Sol at S 3.42)
Ball Mill Discharge:	68.4 % plus 48 mesh
	14.1 % minus 100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	3,221	23.3
Rod Mill Discharge	738	37.3
Ball Mill Feed	873	6.3
Ball Mill Discharge	790	14.1
Column Conc	122	85.8
Screen Undersize	169	74.1
Prim Rghr Conc	70	93.0
Sec Rghr Conc	99	87.3
Sec Rghr Tail	161	76.6
Scavenger Conc	164	74.7
Final Tail	169	74.5

3.2. Reagent Additions:

Average Feed Rate: 0.194 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	NaIX	2.0%	12.0	74.1
	DF-250	2.0%	6.6	40.8
Scavenger 1 Feed	NaIX	2.0%	8.0	49.4
	DF-250	2.0%	2.0	12.3
	CuSO4	2.0%	7.4	45.7
Scavenger 2 Feed	NaIX	2.0%	5.5	34.0
	DF-250	2.0%	2.0	12.3
Total	**NaIX**		25.5	**157.4**
	DF-250		10.6	**65.4**
	CuSO4		7.4	**45.7**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,600			3.42
Ball Mill Discharge				
Screen Feed	1,630			
Screen Undersize	1,150	9.1	15.5	
Scavenger 1 Feed	1,050	8.0		
Scavenger 2 Tail	1,040			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density kg/L	Rate L/min	Time min
Unit Column	41	1,135	1.63	21.2	1.9
Primary Rougher	56	177	1.15	13.9	4.0
Secondary Rougher	28	166	1.10	19.5	1.4
Scavenger	336	161	1.05	37.9	8.9
Total	461				16.2

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 484%** **From BILCO 484%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.36	0.59	10.8	1.39	0.62	10.57	194.4	100.00
Rod Mill Discharge	1.41	0.67	10.8	1.39	0.62	10.57	194.4	100.00
Ball Mill Feed	0.40	0.28	4.74	0.42	0.28	4.57	940.3	483.81
Ball Mill Discharge	0.45	0.29	4.44	0.42	0.28	4.57	940.3	483.81
Unit Column Feed	--	--	--	0.59	0.34	5.59	1,134.7	583.81
Unit Column Conc	7.57	4.48	32.8	7.48	4.43	33.61	17.5	9.00
Screen Feed	--	--	--	0.48	0.28	5.16	1,117.2	574.81
Screen Undersize	0.84	0.21	7.77	0.79	0.24	8.29	176.9	91.00
Prim Rghr Conc	3.78	2.23	25.3	3.87	2.03	25.5	11.2	5.74
Prim Rghr Tail	0.59	0.10	9.54	0.58	0.12	7.14	165.7	85.26
Sec Rghr Conc	3.27	1.24	15.3	3.33	1.12	15.7	4.8	2.48
Sec Rghr Tail	0.49	0.093	7.28	0.50	0.092	6.87	160.9	82.78
Scavenger Conc	2.11	0.370	30.7	2.08	0.301	35.02	27.3	14.04
Scavenger Tail	0.18	0.058	1.10	0.18	0.050	1.12	133.6	68.74

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall	Metal Assays			Mineral Assays			Ratio
	Wt %	% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.39	0.62	10.6	3.40	22.1	1.80	6.5
Combined Conc	31.3	4.07	1.87	31.4	9.89	65.6	5.43	6.6
Final Tail	68.7	0.18	0.05	1.12	0.45	2.3	0.15	5.2
Unit Column Feed	583.8	0.59	0.34	5.59	1.38	12.0	0.99	8.7
Unit Column Conc	9.0	7.48	4.43	33.6	19.23	56.9	12.84	3.0
Unit Column Tail	574.8	0.48	0.28	5.16	1.10	11.3	0.81	10.3
Prim Rghr Feed	91.0	0.79	0.24	8.29	1.83	18.7	0.70	10.2
Prim Rghr Conc	5.7	3.87	2.03	25.5	9.61	50.9	5.88	5.3
Prim Rghr Tail	85.3	0.58	0.12	7.14	1.31	16.5	0.35	12.6
Sec Rghr Feed	85.3	0.58	0.12	7.14	1.31	16.5	0.35	12.6
Sec Rghr Conc	2.5	3.33	1.12	15.7	8.58	29.3	3.25	3.4
Sec Rghr Tail	82.8	0.50	0.09	6.87	1.09	16.1	0.27	14.8
Comb Rghr Feed	91.0	0.79	0.24	8.29	1.83	18.7	0.70	10.2
Comb Rghr Conc	8.2	3.71	1.75	22.6	9.30	44.4	5.09	4.8
Comb Rghr Tail	82.8	0.50	0.09	6.87	1.09	16.1	0.27	14.8
Scavenger Feed	82.8	0.50	0.09	6.87	1.09	16.1	0.27	14.8
Scavenger Conc	14.0	2.08	0.30	35.0	4.23	83.7	0.87	19.8
Scavenger Tail	68.7	0.18	0.05	1.12	0.45	2.3	0.15	5.2
Comb Mech Feed	91.0	0.79	0.24	8.29	1.83	18.7	0.70	10.2
Comb Mech Conc	22.3	2.68	0.83	30.4	6.10	69.2	2.42	11.3
Comb Mech Tail	68.7	0.18	0.05	1.12	0.45	2.3	0.15	5.2
Col + P.Rghr Feed	100.0	1.39	0.62	10.6	3.40	22.1	1.80	6.5
Col + P.Rghr Conc	14.7	6.08	3.50	30.5	15.5	54.5	10.2	3.5
Col + P.Rghr Tail	85.3	0.58	0.12	7.1	1.31	16.5	0.35	12.6

4.3. Metallurgical Balance - Distributions:

Product	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	31.3	91.2	94.5	92.7	90.9	92.8	94.5	8.2
Final Tail	68.7	8.8	5.5	7.3	9.1	7.2	5.5	91.8
Unit Column Feed	583.8	246.3	322.0	308.9	236.9	317.1	322.0	687.6
Unit Column Conc	9.0	48.3	64.3	28.6	50.9	23.1	64.3	1.4
Unit Column Tail	574.8	198.0	257.7	280.3	185.9	294.0	257.7	686.3
Prim Rghr Feed	91.0	51.6	35.5	71.4	49.0	76.9	35.5	98.6
Prim Rghr Conc	5.7	15.9	18.8	13.9	16.2	13.2	18.8	2.7
Prim Rghr Tail	85.3	35.7	16.7	57.5	32.8	63.7	16.7	96.0
Sec Rghr Feed	85.3	35.7	16.8	57.5	32.8	63.7	16.8	96.0
Sec Rghr Conc	2.5	5.9	4.5	3.7	6.3	3.3	4.5	2.0
Sec Rghr Tail	82.8	29.8	12.3	53.9	26.6	60.4	12.3	94.0
Comb Rghr Feed	91.0	51.6	35.5	71.4	49.0	76.9	35.5	98.6
Comb Rghr Conc	8.2	21.9	23.3	17.5	22.5	16.5	23.3	4.7
Comb Rghr Tail	82.8	29.8	12.3	53.8	26.5	60.4	12.3	94.0
Scavenger Feed	82.8	29.8	12.3	53.8	26.5	60.3	12.3	94.0
Scavenger Conc	14.0	20.9	6.8	46.5	17.5	53.1	6.8	2.2
Scavenger Tail	68.7	8.8	5.5	7.3	9.0	7.2	5.5	91.8
Comb Mech Feed	91.0	51.6	35.5	71.4	49.0	76.9	35.5	98.6
Comb Mech Conc	22.3	42.8	30.0	64.1	39.9	69.7	30.0	6.8
Comb Mech Tail	68.7	8.8	5.5	7.3	9.1	7.2	5.5	91.8
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.7	64.3	83.2	42.5	67.2	36.3	83.2	4.0
Col + P.Rghr Tail	85.3	35.7	16.8	57.5	32.8	63.7	16.8	96.0

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	31.3	91.2	94.5	92.7	90.9	92.8	94.5	8.2
Final Tail	68.7	8.8	5.5	7.3	9.1	7.2	5.5	91.8
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	1.5	19.6	20.0	9.3	21.5	7.3	20.0	0.2
Unit Column Tail	98.5	80.4	80.0	90.7	78.5	92.7	80.0	99.8
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	6.3	30.9	52.9	19.4	33.1	17.2	52.9	2.7
Prim Rghr Tail	93.7	69.1	47.1	80.6	66.9	82.8	47.1	97.3
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	2.9	16.6	26.7	6.4	19.1	5.2	26.7	2.1
Sec Rghr Tail	97.1	83.4	73.3	93.6	80.9	94.8	73.3	97.9
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	9.0	42.4	65.5	24.6	45.9	21.5	65.5	4.7
Comb Rghr Tail	91.0	57.6	34.5	75.4	54.1	78.5	34.5	95.3
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	17.0	70.4	55.5	86.4	65.9	88.1	55.5	2.3
Scavenger Tail	83.0	29.6	44.5	13.6	34.1	11.9	44.5	97.7
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	24.5	82.9	84.4	89.8	81.5	90.6	84.4	6.9
Comb Mech Tail	75.5	17.1	15.6	10.2	18.5	9.4	15.6	93.1
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.7	64.3	83.2	42.5	67.2	36.3	83.2	4.0
Col + P.Rghr Tail	85.3	35.7	16.8	57.5	32.8	63.7	16.8	96.0

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	15.8	8.5	8.5	91.5
6	3,327	19.5	10.5	19.0	81.0
8	2,362	16.8	9.1	28.1	71.9
10	1,651	13.6	7.3	35.4	64.6
14	1,168	14.3	7.7	43.1	56.9
20	833	10.8	5.8	48.9	51.1
28	589	11.0	5.9	54.9	45.1
35	417	10.5	5.7	60.5	39.5
48	295	9.7	5.2	65.8	34.2
65	208	9.2	5.0	70.7	29.3
100	147	11.0	5.9	76.7	23.3
150	104	9.5	5.1	81.8	18.2
200	74	8.1	4.4	86.1	13.9
270	53	7.4	4.0	90.1	9.9
400	37	4.9	2.6	92.8	7.2
Pan	-37	13.4	7.2	100.0	-
Total	-	**185.5**	**100.0**	-	-
K80	**3,221**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.2	1.3	1.3	98.7
14	1,168	5.8	3.5	4.9	95.1
20	833	17.3	10.5	15.4	84.6
28	589	20.1	12.2	27.6	72.4
35	417	18.3	11.1	38.7	61.3
48	295	14.3	8.7	47.4	52.6
65	208	11.4	6.9	54.3	45.7
100	147	13.9	8.4	62.7	37.3
150	104	11.1	6.7	69.5	30.5
200	74	10.2	6.2	75.7	24.3
270	53	9.0	5.5	81.1	18.9
400	37	7.2	4.4	85.5	14.5
Pan	-37	23.9	14.5	100.0	-
Total	-	**164.7**	**100.0**	-	-
K80	**738**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	7.3	3.9	3.9	96.1
14	1,168	12.1	6.4	10.3	89.7
20	833	20.0	10.7	21.0	79.0
28	589	29.9	15.9	36.9	63.1
35	417	35.7	19.0	55.9	44.1
48	295	34.4	18.3	74.3	25.7
65	208	25.9	13.8	88.1	11.9
100	147	10.6	5.6	93.7	6.3
150	104	4.6	2.5	96.2	3.8
200	74	2.4	1.3	97.4	2.6
270	53	1.5	0.8	98.2	1.8
400	37	0.9	0.5	98.7	1.3
Pan	-37	2.4	1.3	100.0	-
Total	-	**187.7**	**100.0**	-	-
K80	**873**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.5	2.8	2.8	97.2
14	1,168	12.2	5.3	8.2	91.8
20	833	21.9	9.6	17.8	82.2
28	589	35.0	15.3	33.1	66.9
35	417	41.8	18.3	51.5	48.5
48	295	38.6	16.9	68.4	31.6
65	208	25.5	11.2	79.6	20.4
100	147	14.5	6.4	85.9	14.1
150	104	8.3	3.6	89.6	10.4
200	74	5.6	2.5	92.0	8.0
270	53	4.1	1.8	93.8	6.2
400	37	3.0	1.3	95.1	4.9
Pan	-37	11.1	4.9	100.0	-
Total	-	**228.1**	**100.0**	-	-
K80	**790**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	7.9	9.9	9.9	90.1
100	147	12.7	16.0	25.9	74.1
150	104	10.3	13.0	38.9	61.1
200	74	8.6	10.8	49.7	50.3
270	53	7.8	9.8	59.6	40.4
400	37	5.9	7.4	67.0	33.0
Pan	-37	26.2	33.0	100.0	-
Total	-	**79.4**	**100.0**	-	-
K80	**169.2**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.0	3.3	3.3	96.7
100	147	3.4	3.7	7.0	93.0
150	104	4.4	4.8	11.8	88.2
200	74	6.0	6.6	18.4	81.6
270	53	8.3	9.1	27.5	72.5
400	37	8.5	9.3	36.8	63.2
Pan	-37	57.7	63.2	100.0	-
Total	-	**91.3**	**100.0**	-	-
K80	**69.9**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.7	9.0	9.0	91.0
100	147	1.1	3.7	12.7	87.3
150	104	1.7	5.7	18.4	81.6
200	74	3.6	12.0	30.4	69.6
270	53	3.9	13.0	43.5	56.5
400	37	2.5	8.4	51.8	48.2
Pan	-37	14.4	48.2	100.0	-
Total	-	**29.9**	**100.0**	-	-
K80	**99.3**				

Secondary Rougher Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	12.2	9.4	9.4	90.6
100	147	18.2	14.0	23.4	76.6
150	104	16.9	13.0	36.4	63.6
200	74	15.4	11.9	48.3	51.7
270	53	13.0	10.0	58.3	41.7
400	37	9.9	7.6	65.9	34.1
Pan	-37	44.3	34.1	100.0	-
Total	-	**129.9**	**100.0**	-	-
K80	**160.5**				

Scavenger Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	4.3	8.2	8.2	91.8
100	147	8.9	17.0	25.3	74.7
150	104	8.0	15.3	40.6	59.4
200	74	7.6	14.6	55.2	44.8
270	53	7.3	14.0	69.2	30.8
400	37	3.9	7.5	76.6	23.4
Pan	-37	12.2	23.4	100.0	-
Total	-	**52.2**	**100.0**	-	-
K80	**163.9**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	19.6	10.7	10.7	89.3
100	147	27.0	14.8	25.5	74.5
150	104	22.0	12.0	37.6	62.4
200	74	18.9	10.4	47.9	52.1
270	53	15.9	8.7	56.6	43.4
400	37	12.7	7.0	63.6	36.4
Pan	-37	66.5	36.4	100.0	-
Total	-	**182.6**	**100.0**	-	-
K80	**169.0**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	12.2	6.4	6.4	93.6
100	147	14.9	7.8	14.2	85.8
150	104	20.2	10.6	24.9	75.1
200	74	25.8	13.6	38.4	61.6
270	53	27.2	14.3	52.7	47.3
400	37	22.3	11.7	64.4	35.6
Pan	-37	67.7	35.6	100.0	-
Total	-	**190.3**	**100.0**	-	-
K80	**121.8**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data

(based on 60 mesh Kason screen with 234 µm aperture)

C L R
484%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	47.4	68.4	74.3	0.0
-48+100	15.4	17.5	19.4	25.9
-100+200	12.9	6.1	3.7	23.8
-200+400	9.8	3.1	1.3	17.3
-400	14.5	4.9	1.3	33.0

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	806 %	66.1	532 %
-48+100	-554 %	18.0	-100 %
-100+200	460 %	7.3	34 %
-200+400	404 %	4.4	18 %
-400	515 %	4.2	21 %
Total		100.0	484 %

1. Purpose: Test without the unit column, try to increase circulating load in the grinding circuit.

2. Procedure: All process units started with the exception of the unit column.

2.1. Flowsheet: The flowsheet is shown in Figure 1b.

2.2. Equipment: The equipment list is shown in Table 1b.

3. Results:

Flotation Feed Size		59.90 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.36	0.61	3.37	1.76	5.59
Unit Column	Grade	--	--	--	--	--
	Recov	--	--	--	--	--
Primary Rougher	Grade	8.87	9.44	22.9	27.4	1.89
	Recov	24.8	59.1	25.8	59.1	0.33
Secondary Rougher	Grade	9.50	5.48	25.0	15.9	1.54
	Recov	16.3	21.0	17.3	21.0	0.63
Scavenger	Grade	2.77	0.34	6.57	0.98	9.1
	Recov	45.5	12.5	43.6	12.5	9.66
Overall Circuit	Grade	4.14	1.98	10.2	5.73	5.43
	Recov	86.5	92.6	86.7	92.6	10.63

Able to increase the circulating load to nearly 800%. Reagents were reduced and this resulted in a higher grade concentrate.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	208.8 kg/h of -1/4 inch feed (Wet Sple 1221.7 g)
	(Dry Sple 1214.7 g)
Feed Rate:	207.6 kg/h of dry ore. (Moisture 0.57 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 574 kg in 2.75 hr
	Sample 209 kg in 1.00 hr
Rod Mill Discharge:	1,600 g/L (54 % Sol at Solid SG of 3.33)
	41.9 % plus 48 mesh
	42.8 % minus 100 mesh
Input Power:	36.85 for 3 disc revolutions
	1.06 kW (95% drive efficiency)
Average Power:	1.00 kW Gross
	0.47 kW No Load
	0.53 kW Net
Net Power Usage:	2.54 kWh/tonne of -1/4 inch feed.
K80 Feed:	3,206 microns
K80 Product:	714 microns
Work Index (metric):	12.9

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 790 % circ. load)
Feed Rate:	1,640.1 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,237 g/L (27 % Sol at S 3.33)
Ball Mill Discharge:	1,627 g/L (55 % Sol at S 3.33)
	76.2 % plus 48 mesh
	8.5 % minus 100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	3,206	28.2
Rod Mill Discharge	714	42.8
Ball Mill Feed	1,073	6.6
Ball Mill Discharge	1,030	8.5
Screen Feed	1,007	15.8
Screen Undersize	148	79.8
Prim Rghr Conc	71	94.2
Sec Rghr Conc	46	96.4
Sec Rghr Tail	62	95.5
Scavenger Conc	143	81.5
Final Tail	164	75.8

3.2. Reagent Additions:

Average Feed Rate: 0.208 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	NaIX	2.0%	5.3	30.6
	DF-250	2.0%	2.7	15.6
Scavenger 1 Feed	NaIX	2.0%	3.6	20.8
	DF-250	2.0%	2.7	15.6
	CuSO4	2.0%	6.5	37.6
Scavenger 2 Feed	NaIX	2.0%	4.9	28.3
	DF-250	2.0%	3.0	17.3
Total	**NaIX**		13.8	**79.8**
	DF-250		8.4	**48.6**
	CuSO4		6.5	**37.6**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,693			3.33
Ball Mill Discharge	1,627			
Screen Feed	--			
Screen Undersize	1,237	9.4	20.0	
Scavenger Feed	1,183	8.5		
Final Tail	1,175			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Primary Rougher	56	208	1.24	10.2	5.5
Secondary Rougher	28	200	1.20	11.6	2.4
Scavenger	336	195	1.18	12.4	27.1
Total	420				

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 1210%** **From BILCO 790%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.32	0.59	9.83	1.36	0.61	9.2	207.6	100.00
Rod Mill Discharge	1.32	0.59	10.1	1.36	0.61	9.2	207.6	100.00
Ball Mill Feed	0.48	0.34	5.46	0.51	0.34	5.70	1,640.1	790.00
Ball Mill Discharge	0.52	0.32	5.96	0.51	0.34	5.70	1,640.1	790.00
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Screen Feed	0.63	0.38	6.06	0.60	0.37	6.10	1,847.7	890.00
Screen Undersize	1.54	0.66	13.0	1.36	0.61	9.24	207.6	100.00
Prim Rghr Conc	8.84	9.53	32.9	8.87	9.44	34.6	7.9	3.81
Prim Rghr Tail	1.38	0.24	11.1	1.06	0.26	8.24	199.7	96.19
Sec Rghr Conc	9.14	5.75	28.1	9.50	5.48	29.4	4.8	2.33
Sec Rghr Tail	0.82	0.120	5.49	0.86	0.13	7.72	194.9	93.86
Scavenger Conc	2.58	0.37	28.4	2.77	0.34	26.2	46.4	22.35
Scavenger Tail	0.25	0.066	1.96	0.26	0.06	1.93	148.5	71.52

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

	Overall	Metal Assays			Mineral Assays			Ratio
Product	Wt %	% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.36	0.61	9.2	3.37	18.8	1.76	5.6
Combined Conc	28.5	4.14	1.98	27.6	10.25	55.6	5.73	5.4
Final Tail	71.5	0.26	0.06	1.93	0.63	4.2	0.18	6.6
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	1.36	0.61	9.24	3.37	18.8	1.76	5.6
Prim Rghr Conc	3.8	8.87	9.44	34.6	22.86	43.1	27.39	1.9
Prim Rghr Tail	96.2	1.06	0.26	8.24	2.60	17.9	0.75	6.9
Sec Rghr Feed	96.2	1.06	0.26	8.24	2.60	17.9	0.75	6.9
Sec Rghr Conc	2.3	9.50	5.48	29.4	25.04	38.6	15.89	1.5
Sec Rghr Tail	93.9	0.86	0.13	7.72	2.04	17.3	0.37	8.5
Comb Rghr Feed	100.0	1.36	0.61	9.24	3.37	18.8	1.76	5.6
Comb Rghr Conc	6.1	9.11	7.94	32.6	23.69	41.4	23.03	1.7
Comb Rghr Tail	93.9	0.86	0.13	7.72	2.04	17.3	0.37	8.5
Scavenger Feed	93.9	0.86	0.13	7.72	2.04	17.3	0.37	8.5
Scavenger Conc	22.3	2.77	0.34	26.2	6.57	59.6	0.98	9.1
Scavenger Tail	71.5	0.26	0.06	1.93	0.63	4.2	0.18	6.6
Comb Mech Feed	100.0	1.36	0.61	9.24	3.37	18.8	1.76	5.6
Comb Mech Conc	28.5	4.14	1.98	27.6	10.25	55.6	5.73	5.4
Comb Mech Tail	71.5	0.26	0.06	1.93	0.63	4.2	0.18	6.6
Col + P.Rghr Feed	100.0	1.36	0.61	9.2	3.37	18.8	1.76	5.6
Col + P.Rghr Conc	3.8	8.87	9.45	34.6	22.8	43.1	27.4	1.9
Col + P.Rghr Tail	96.2	1.06	0.26	8.2	2.60	17.9	0.75	6.9

4.3. Metallurgical Balance - Distributions:

	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
Product	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	28.5	86.5	92.6	85.1	86.7	84.2	92.6	10.6
Final Tail	71.5	13.5	7.4	14.9	13.3	15.8	7.4	89.4
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	3.8	24.8	59.1	14.2	25.8	8.7	59.1	0.3
Prim Rghr Tail	96.2	75.2	40.9	85.8	74.2	91.3	40.9	99.7
Sec Rghr Feed	96.2	75.2	40.8	85.8	74.2	91.3	40.8	99.7
Sec Rghr Conc	2.3	16.3	21.0	7.4	17.3	4.8	21.0	0.6
Sec Rghr Tail	93.9	58.9	19.8	78.3	56.9	86.5	19.8	99.0
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	6.1	41.1	80.1	21.6	43.2	13.5	80.1	1.0
Comb Rghr Tail	93.9	58.9	19.9	78.4	56.8	86.5	19.9	99.0
Scavenger Feed	93.9	59.0	19.9	78.4	56.9	86.5	19.9	99.0
Scavenger Conc	22.3	45.5	12.5	63.5	43.6	70.7	12.5	9.7
Scavenger Tail	71.5	13.4	7.5	14.9	13.3	15.8	7.5	89.4
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	28.5	86.5	92.6	85.1	86.7	84.2	92.6	10.6
Comb Mech Tail	71.5	13.5	7.4	14.9	13.3	15.8	7.4	89.4
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	3.8	24.8	59.2	14.2	25.8	8.7	59.2	0.3
Col + P.Rghr Tail	96.2	75.2	40.8	85.8	74.2	91.3	40.8	99.7

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	28.5	86.5	92.6	85.1	86.7	84.2	92.6	10.6
Final Tail	71.5	13.5	7.4	14.9	13.3	15.8	7.4	89.4
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	3.8	24.8	59.1	14.2	25.8	8.7	59.1	0.3
Prim Rghr Tail	96.2	75.2	40.9	85.8	74.2	91.3	40.9	99.7
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	2.4	21.6	51.4	8.6	23.3	5.2	51.4	0.6
Sec Rghr Tail	97.6	78.4	48.6	91.4	76.7	94.8	48.6	99.4
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	6.1	41.1	80.1	21.6	43.2	13.5	80.1	1.0
Comb Rghr Tail	93.9	58.9	19.9	78.4	56.8	86.5	19.9	99.0
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	23.8	77.2	62.6	81.0	76.6	81.7	62.6	9.8
Scavenger Tail	76.2	22.8	37.4	19.0	23.4	18.3	37.4	90.2
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	28.5	86.5	92.6	85.1	86.7	84.2	92.6	10.6
Comb Mech Tail	71.5	13.5	7.4	14.9	13.3	15.8	7.4	89.4
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	3.8	24.8	59.2	14.2	25.8	8.7	59.2	0.3
Col + P.Rghr Tail	96.2	75.2	40.8	85.8	74.2	91.3	40.8	99.7

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	15.3	3.2	3.2	96.8
6	3,327	73.1	15.3	18.5	81.5
8	2,362	57.7	12.1	30.6	69.4
10	1,651	50.4	10.6	41.1	58.9
14	1,168	34.9	7.3	48.5	51.5
20	833	24.9	5.2	53.7	46.3
28	589	21.2	4.4	58.1	41.9
35	417	19.4	4.1	62.2	37.8
48	295	15.2	3.2	65.3	34.7
65	208	15.2	3.2	68.5	31.5
100	147	15.5	3.2	71.8	28.2
150	104	13.3	2.8	74.6	25.4
200	74	12.0	2.5	77.1	22.9
270	53	10.9	2.3	79.4	20.6
400	37	8.3	1.7	81.1	18.9
Pan	-37	90.3	18.9	100.0	-
Total	-	**477.6**	**100.0**	-	-
K80	**3,206**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.4	1.9	1.9	98.1
14	1,168	8.7	5.0	6.9	93.1
20	833	14.7	8.4	15.4	84.6
28	589	17.0	9.7	25.1	74.9
35	417	16.3	9.3	34.5	65.5
48	295	13.0	7.5	41.9	58.1
65	208	12.9	7.4	49.3	50.7
100	147	13.7	7.9	57.2	42.8
150	104	11.5	6.6	63.8	36.2
200	74	10.9	6.3	70.0	30.0
270	53	10.1	5.8	75.8	24.2
400	37	8.6	4.9	80.7	19.3
Pan	-37	33.6	19.3	100.0	-
Total	-	**174.4**	**100.0**	-	-
K80	**714**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	12.3	5.1	5.1	94.9
14	1,168	27.1	11.2	16.2	83.8
20	833	36.9	15.2	31.4	68.6
28	589	41.4	17.1	48.5	51.5
35	417	39.8	16.4	64.9	35.1
48	295	34.4	14.2	79.1	20.9
65	208	24.4	10.1	89.1	10.9
100	147	10.4	4.3	93.4	6.6
150	104	4.9	2.0	95.4	4.6
200	74	2.9	1.2	96.6	3.4
270	53	2.0	0.8	97.4	2.6
400	37	1.3	0.5	98.0	2.0
Pan	-37	4.9	2.0	100.0	-
Total	-	**242.7**	**100.0**	-	-
K80	**1,073**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	13.8	4.8	4.8	95.2
14	1,168	29.0	10.1	14.9	85.1
20	833	39.9	13.9	28.7	71.3
28	589	47.1	16.4	45.1	54.9
35	417	46.4	16.1	61.2	38.8
48	295	43.0	14.9	76.2	23.8
65	208	30.6	10.6	86.8	13.2
100	147	13.4	4.7	91.5	8.5
150	104	7.1	2.5	94.0	6.0
200	74	4.6	1.6	95.6	4.4
270	53	3.2	1.1	96.7	3.3
400	37	2.4	0.8	97.5	2.5
Pan	-37	7.2	2.5	100.0	-
Total	-	**287.7**	**100.0**	-	-
K80	**1,030**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	17.5	5.2	5.2	94.8
14	1,168	31.5	9.3	14.5	85.5
20	833	42.0	12.5	27.0	73.0
28	589	50.1	14.9	41.8	58.2
35	417	48.6	14.4	56.3	43.7
48	295	43.7	13.0	69.2	30.8
65	208	32.3	9.6	78.8	21.2
100	147	18.2	5.4	84.2	15.8
150	104	11.9	3.5	87.7	12.3
200	74	10.1	3.0	90.7	9.3
270	53	6.9	2.0	92.8	7.2
400	37	3.9	1.2	93.9	6.1
Pan	-37	20.5	6.1	100.0	-
Total	-	**337.2**	**100.0**	-	-
K80	**1,007**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	6.1	6.8	6.8	93.2
100	147	12.1	13.4	20.2	79.8
150	104	11.4	12.6	32.8	67.2
200	74	10.0	11.1	43.9	56.1
270	53	9.8	10.9	54.7	45.3
400	37	6.8	7.5	62.2	37.8
Pan	-37	34.1	37.8	100.0	-
Total	-	**90.3**	**100.0**	-	-
K80	**148.1**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.1	1.3	1.3	98.7
100	147	3.6	4.4	5.8	94.2
150	104	4.4	5.4	11.1	88.9
200	74	6.3	7.7	18.8	81.2
270	53	8.1	9.9	28.8	71.2
400	37	9.1	11.1	39.9	60.1
Pan	-37	49.1	60.1	100.0	-
Total	-	**81.7**	**100.0**	-	-
K80	**71.1**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.5	0.8	0.8	99.2
100	147	1.8	2.8	3.6	96.4
150	104	2.0	3.1	6.8	93.2
200	74	2.9	4.6	11.3	88.7
270	53	3.7	5.8	17.1	82.9
400	37	4.7	7.4	24.5	75.5
Pan	-37	48.1	75.5	100.0	-
Total	-	**63.7**	**100.0**	-	-
K80	**46.0**				

Secondary Rougher Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.7	1.6	1.6	98.4
100	147	1.3	2.9	4.5	95.5
150	104	2.0	4.5	9.0	91.0
200	74	2.9	6.6	15.6	84.4
270	53	3.8	8.6	24.2	75.8
400	37	4.5	10.2	34.4	65.6
Pan	-37	29.0	65.6	100.0	-
Total	-	**44.2**	**100.0**	-	-
K80	**62.2**				

Scavenger Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.1	4.3	4.3	95.7
100	147	10.3	14.2	18.5	**81.5**
150	104	12.4	17.1	35.5	64.5
200	74	11.1	15.3	50.8	49.2
270	53	8.6	11.8	62.7	37.3
400	37	6.4	8.8	71.5	28.5
Pan	-37	20.7	28.5	100.0	-
Total	-	**72.6**	**100.0**	-	-
K80	**142.7**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	18.4	9.6	9.6	90.4
100	147	27.8	14.5	24.2	**75.8**
150	104	23.4	12.2	36.4	63.6
200	74	20.3	10.6	47.0	53.0
270	53	17.2	9.0	56.0	44.0
400	37	14.1	7.4	63.4	36.6
Pan	-37	70.1	36.6	100.0	-
Total	-	**191.3**	**100.0**	-	-
K80	**163.5**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 μm aperture)

C L R
1210%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	41.9	76.2	79.1	0.0
-48+100	15.3	15.3	14.3	20.2
-100+200	12.8	4.1	3.2	23.7
-200+400	10.7	1.9	1.4	18.4
-400	19.3	2.5	2.0	37.8

Size (mesh)	Fractional CLR	Measured SFD	Prop'n CLR
+48	1456 %	69.2	1008 %
-48+100	513 %	15.0	77 %
-100+200	1273 %	6.5	83 %
-200+400	1306 %	3.2	42 %
-400	3824 %	6.1	233 %
Total		100.0	**1210 %**

1. **Purpose:** To improve concentrate grades by reducing collector dosage.

2. **Procedure:** All process units started with the exception of the unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		80.6 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.39	0.64	3.38	1.85	6.74
Unit Column	Grade	--	--	--	--	--
	Recov	--	--	--	--	--
Primary Rougher	Grade	6.31	12.2	15.6	35.4	2.37
	Recov	19.7	83.2	20.1	83.2	0.71
Secondary Rougher	Grade	4.12	3.28	10.2	9.50	4.94
	Recov	1.2	2.1	1.2	2.1	0.17
Scavenger	Grade	--	--	--	--	--
	Recov	--	--	--	--	--
Overall Circuit	Grade	6.12	11.4	15.2	33.2	2.52
	Recov	20.9	85.3	21.3	85.3	0.89

Collector dosage was cut to 100 g/t from 160 g/t. There was no improvement in grade, but nickel recovery fell sharply to 21%.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	199.3 kg/h of -1/4 inch feed. (Wet Sple 1135.6 g)
	(Dry Sple 1111.0 g)
Feed Rate:	195.0 kg/h of dry ore. (Moisture 2.17 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 548 kg in 2.75 hr
	Sample 199 kg in 1.00 hr
Rod Mill Discharge:	1,670 g/L (57 % Sol at Solid SG of 3.39)
	40.7 % plus 48 mesh
	42.0 % minus 100 mesh
Input Power:	31.05 for 3 disc revolutions
	1.25 kW (95% drive efficiency)
Average Power:	1.19 kW Gross
	0.47 kW No Load
	0.72 kW Net
Net Power Usage:	3.67 kWh/tonne of -1/4 inch feed.
K80 Feed:	3,680 microns
K80 Product:	572 microns
Work Index (metric):	14.5

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 83 % circ. load)
Feed Rate:	162.0 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,347 g/L (37 % Sol at S 3.39)
Ball Mill Discharge:	1,730 g/L (60 % Sol at S 3.39)
	9.5 % plus 48 mesh
	66.4 % minus 100 mesh
Input Power:	34.83 for 3 disc revolutions
	1.12 kW (95% drive efficiency)
Average Power:	1.06 kW Gross
	0.52 kW No Load
	0.54 kW Net
Net Power Usage:	3.32 kWh/tonne of screen oversize.
K80 Feed:	572 microns
K80 Product:	145 microns
Work Index (metric):	8.0

3.1.3. Overall Mill Report:

Net Power Usage:	6.99 kWh/t
K80 Feed:	3,680 microns
K80 Product:	145 microns
Work Index (metric):	10.5
Screen Undersize:	80.6 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	3,680	22.1
Rod Mill Discharge	572	42.0
Ball Mill Feed	694	8.4
Ball Mill Discharge	207	66.4
Screen Feed	432	52.9
Screen Undersize	145	80.6
Prim Rghr Conc	83	92.6
Sec Rghr Conc	29	94.8
Sec Rghr Tail	142	81.4

3.2. Reagent Additions:

Average Feed Rate: 0.195 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	NaIX	2.0%	6.4	39.4
	DF-250	2.0%	3.8	23.4
Scavenger 1 Feed	NaIX	2.0%	4.0	24.6
	DF-250	2.0%	2.0	12.3
	CuSO4	2.0%	5.7	35.1
Scavenger 2 Feed	NaIX	2.0%	5.6	34.5
	DF-250	2.0%	3.4	20.9
Total	**NaIX**		16.0	**98.5**
	DF-250		9.2	**56.6**
	CuSO4		5.7	**35.1**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,670			3.39
Ball Mill Discharge	1,730			
Screen Feed	1,530			
Screen Undersize	1,347	11.5	23.0	
Scavenger 1 Feed	1,330	11.3		
Scavenger 2 Tail	1,270			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Primary Rougher	56	195	1.15	15.3	3.7
Secondary Rougher	28	187	1.10	21.9	1.3
Scavenger	336	186	1.05	43.6	7.7
Total	420				12.6

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 86%** **From BILCO 83%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.32	0.62	10.3	1.39	0.64	10.85	195.0	100.00
Rod Mill Discharge	1.42	0.64	11.1	1.39	0.64	10.85	195.0	100.00
Ball Mill Feed	0.65	0.40	7.82	0.66	0.41	7.92	162.0	83.06
Ball Mill Discharge	0.68	0.42	8.18	0.66	0.41	7.92	162.0	83.06
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Screen Feed	1.04	0.57	9.05	1.06	0.54	9.52	357.0	183.06
Screen Undersize	1.47	0.66	11.6	1.39	0.64	10.85	195.0	100.00
Prim Rghr Conc	6.38	12.1	32.9	6.31	12.22	32.7	8.5	4.34
Prim Rghr Tail	1.13	0.11	9.74	1.17	0.11	9.86	186.5	95.66
Sec Rghr Conc	4.12	3.28	26.7	4.12	3.28	26.8	0.8	0.41
Sec Rghr Tail	1.27	0.10	10.5	1.16	0.098	9.78	185.7	95.24
Scavenger Conc	--	--	--	--	--	--	--	--
Scavenger Tail	--	--	--	--	--	--	--	--

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite % Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite % Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite % Cp = (2.90 x %Cu)
Gangue % Ga = 100 - Pn - Po - Cp

	Overall	Metal Assays			Mineral Assays			Ratio
Product	Wt %	% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.4	0.6	10.8	3.4	22.8	1.9	6.7
Combined Conc	4.8	6.1	11.4	32.2	15.2	38.2	33.2	2.5
Final Tail	95.2	1.2	0.1	9.8	2.8	22.0	0.3	7.9
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	1.39	0.64	10.85	3.38	22.8	1.85	6.7
Prim Rghr Conc	4.3	6.31	12.22	32.7	15.64	37.1	35.44	2.4
Prim Rghr Tail	95.7	1.17	0.11	9.86	2.82	22.1	0.32	7.8
Sec Rghr Feed	95.7	1.17	0.11	9.86	2.82	22.1	0.32	7.8
Sec Rghr Conc	0.4	4.12	3.28	26.8	10.18	50.3	9.50	4.9
Sec Rghr Tail	95.2	1.16	0.10	9.78	2.79	22.0	0.28	7.9
Comb Rghr Feed	100.0	1.39	0.64	10.85	3.38	22.8	1.85	6.7
Comb Rghr Conc	4.8	6.12	11.45	32.2	15.16	38.2	33.19	2.5
Comb Rghr Tail	95.2	1.16	0.10	9.78	2.79	22.0	0.28	7.9
Scavenger Feed	--	--	--	--	--	--	--	--
Scavenger Conc	--	--	--	--	--	--	--	--
Scavenger Tail	--	--	--	--	--	--	--	--
Comb Mech Feed	--	--	--	--	--	--	--	--
Comb Mech Conc	--	--	--	--	--	--	--	--
Comb Mech Tail	--	--	--	--	--	--	--	--
Col + P.Rghr Feed	100.0	1.39	0.64	10.8	3.38	22.8	1.85	6.7
Col + P.Rghr Conc	4.3	6.30	12.22	32.7	15.6	37.1	35.4	2.4
Col + P.Rghr Tail	95.7	1.17	0.11	9.9	2.82	22.1	0.32	7.8

4.3. Metallurgical Balance - Distributions:

Product	Overall Wt %	Metal Distributions (%)			Mineral Distributions (%)			Gangue
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	4.8	20.9	85.3	14.1	21.3	8.0	85.3	0.9
Final Tail	95.2	79.1	14.7	85.9	78.7	92.0	14.7	99.1
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	4.3	19.7	83.2	13.1	20.1	7.1	83.2	0.7
Prim Rghr Tail	95.7	80.3	16.8	86.9	79.9	92.9	16.8	99.3
Sec Rghr Feed	95.7	80.3	16.8	86.9	79.9	92.9	16.8	99.3
Sec Rghr Conc	0.4	1.2	2.1	1.0	1.2	0.9	2.1	0.2
Sec Rghr Tail	95.2	79.1	14.7	85.9	78.7	92.0	14.7	99.1
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	4.8	20.9	85.3	14.1	21.3	8.0	85.3	0.9
Comb Rghr Tail	95.2	79.1	14.7	85.9	78.7	92.0	14.7	99.1
Scavenger Feed	--	--	--	--	--	--	--	--
Scavenger Conc	--	--	--	--	--	--	--	--
Scavenger Tail	--	--	--	--	--	--	--	--
Comb Mech Feed	--	--	--	--	--	--	--	--
Comb Mech Conc	--	--	--	--	--	--	--	--
Comb Mech Tail	--	--	--	--	--	--	--	--
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	4.3	19.7	83.2	13.1	20.1	7.1	83.2	0.7
Col + P.Rghr Tail	95.7	80.3	16.8	86.9	79.9	92.9	16.8	99.3

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	4.8	20.9	85.3	14.1	21.3	8.0	85.3	0.9
Final Tail	95.2	79.1	14.7	85.9	78.7	92.0	14.7	99.1
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	4.3	19.7	83.2	13.1	20.1	7.1	83.2	0.7
Prim Rghr Tail	95.7	80.3	16.8	86.9	79.9	92.9	16.8	99.3
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	0.4	1.5	12.6	1.2	1.6	1.0	12.6	0.2
Sec Rghr Tail	99.6	98.5	87.4	98.8	98.4	99.0	87.4	99.8
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	4.8	20.9	85.3	14.1	21.3	8.0	85.3	0.9
Comb Rghr Tail	95.2	79.1	14.7	85.9	78.7	92.0	14.7	99.1
Scavenger Feed	--	--	--	--	--	--	--	--
Scavenger Conc	--	--	--	--	--	--	--	--
Scavenger Tail	--	--	--	--	--	--	--	--
Comb Mech Feed	--	--	--	--	--	--	--	--
Comb Mech Conc	--	--	--	--	--	--	--	--
Comb Mech Tail	--	--	--	--	--	--	--	--
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	4.3	19.7	83.2	13.1	20.1	7.1	83.2	0.7
Col + P.Rghr Tail	95.7	80.3	16.8	86.9	79.9	92.9	16.8	99.3

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	65.7	10.5	10.5	89.5
6	3,327	77.5	12.4	22.9	77.1
8	2,362	78.2	12.5	35.5	64.5
10	1,651	58.1	9.3	44.8	55.2
14	1,168	45.7	7.3	52.1	47.9
20	833	34.3	5.5	57.6	42.4
28	589	30.5	4.9	62.5	37.5
35	417	27.6	4.4	66.9	33.1
48	295	22.4	3.6	70.5	29.5
65	208	22.9	3.7	74.2	25.8
100	147	23.5	3.8	77.9	22.1
150	104	20.4	3.3	81.2	18.8
200	74	19.5	3.1	84.3	15.7
270	53	18.3	2.9	87.3	12.7
400	37	14.5	2.3	89.6	10.4
Pan	-37	65.0	10.4	100.0	-
Total	-	**624.1**	**100.0**	-	-
K80	**3,680**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.7	0.3	0.3	99.7
14	1,168	4.0	1.7	2.0	98.0
20	833	13.2	5.6	7.6	92.4
28	589	26.5	11.2	18.8	81.2
35	417	29.1	12.3	31.1	68.9
48	295	22.8	9.6	40.7	59.3
65	208	21.3	9.0	49.7	50.3
100	147	19.4	8.2	58.0	42.0
150	104	16.3	6.9	64.8	35.2
200	74	15.1	6.4	71.2	28.8
270	53	13.0	5.5	76.7	23.3
400	37	11.0	4.7	81.4	18.6
Pan	-37	44.0	18.6	100.0	-
Total	-	**236.4**	**100.0**	-	-
K80	**572**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.3	0.6	0.6	99.4
14	1,168	5.2	2.5	3.1	96.9
20	833	16.4	7.9	11.1	88.9
28	589	35.0	16.9	28.0	72.0
35	417	41.6	20.1	48.1	51.9
48	295	41.9	20.3	68.4	31.6
65	208	33.0	16.0	84.4	15.6
100	147	15.0	7.3	91.6	8.4
150	104	5.6	2.7	94.3	5.7
200	74	2.7	1.3	95.6	4.4
270	53	1.7	0.8	96.5	3.5
400	37	1.2	0.6	97.0	3.0
Pan	-37	6.1	3.0	100.0	-
Total	-	**206.7**	**100.0**	-	-
K80	**694**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.0	0.0	0.0	100.0
14	1,168	0.3	0.2	0.2	99.8
20	833	0.6	0.4	0.6	99.4
28	589	1.5	1.0	1.5	98.5
35	417	4.0	2.5	4.1	95.9
48	295	8.5	5.4	9.5	90.5
65	208	16.1	10.3	19.7	80.3
100	147	21.7	13.8	33.6	66.4
150	104	20.3	12.9	46.5	53.5
200	74	18.0	11.5	58.0	42.0
270	53	15.4	9.8	67.8	32.2
400	37	11.5	7.3	75.1	24.9
Pan	-37	39.1	24.9	100.0	-
Total	-	**157.0**	**100.0**	-	-
K80	**207**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.5	0.2	0.2	99.8
14	1,168	2.3	1.1	1.4	98.6
20	833	7.2	3.6	5.0	95.0
28	589	15.1	7.5	12.5	87.5
35	417	17.4	8.6	21.1	78.9
48	295	15.9	7.9	29.0	71.0
65	208	17.8	8.8	37.8	62.2
100	147	18.7	9.3	47.1	**52.9**
150	104	17.6	8.7	55.8	44.2
200	74	16.7	8.3	64.1	35.9
270	53	14.4	7.1	71.3	28.7
400	37	11.5	5.7	77.0	23.0
Pan	-37	46.4	23.0	100.0	-
Total	-	**201.5**	**100.0**	-	-
K80	**432**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	7.3	6.3	6.3	93.7
100	147	15.3	13.2	19.4	**80.6**
150	104	15.8	13.6	33.0	67.0
200	74	14.8	12.7	45.7	54.3
270	53	13.2	11.3	57.1	42.9
400	37	10.0	8.6	65.7	34.3
Pan	-37	39.9	34.3	100.0	-
Total	-	**116.3**	**100.0**	-	-
K80	**144.9**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.8	1.7	1.7	98.3
100	147	9.2	5.7	7.4	92.6
150	104	11.0	6.8	14.3	85.7
200	74	13.6	8.4	22.7	77.3
270	53	16.6	10.3	33.0	67.0
400	37	19.9	12.3	45.3	54.7
Pan	-37	88.2	54.7	100.0	-
Total	-	**161.3**	**100.0**	-	-
K80	**82.6**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.9	1.8	1.8	98.2
100	147	5.5	3.4	5.2	94.8
150	104	5.1	3.1	8.3	91.7
200	74	6.0	3.7	12.0	88.0
270	53	9.0	5.5	17.5	82.5
400	37	12.1	7.5	25.0	75.0
Pan	-37	121.8	75.0	100.0	-
Total	-	**162.4**	**100.0**	-	-
K80	**29.2**				

Secondary Rougher Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	9.1	5.9	5.9	94.1
100	147	19.7	12.7	18.6	81.4
150	104	21.6	14.0	32.6	67.4
200	74	21.3	13.8	46.3	53.7
270	53	18.1	11.7	58.0	42.0
400	37	13.1	8.5	66.5	33.5
Pan	-37	51.9	33.5	100.0	-
Total	-	**154.8**	**100.0**	-	-
K80	**142.0**				

Test No. PP-28

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 µm aperture)

C L R
86%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	40.7	9.5	68.4	0.0
-48+100	17.2	24.1	23.2	19.4
-100+200	13.3	24.4	4.0	26.3
-200+400	10.2	17.1	1.4	19.9
-400	18.6	24.9	3.0	34.3

Size (mesh)	Fractional CLR	Measured SFD	Prop'n CLR
+48	69 %	29.0	20 %
-48+100	259 %	18.1	47 %
-100+200	64 %	17.0	11 %
-200+400	62 %	12.9	8 %
-400	71 %	23.0	16 %
Total		100.0	**86 %**

1. **Purpose:** To improve recovery.

2. **Procedure:** All process units started with the exception of the unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		59.90 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.46	0.68	3.57	1.98	6.37
Unit Column	Grade	--	--	--	--	--
	Recov	--	--	--	--	--
Primary Rougher	Grade	6.49	4.91	16.47	14.24	3.41
	Recov	51.8	84.0	53.8	84.0	2.15
Secondary Rougher	Grade	3.99	1.26	9.84	3.64	5.96
	Recov	3.5	2.4	3.6	2.4	0.50
Scavenger	Grade	1.95	0.24	4.39	0.70	12.4
	Recov	35.5	9.5	32.8	9.5	15.10
Overall Circuit	Grade	3.35	1.65	8.13	4.78	6.76
	Recov	90.9	95.8	90.2	95.8	17.75

Collector dosage was increased to 124 g/t, and the nickel recovery improved to 91% from 21%.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	192.8 kg/h of -1/4 inch feed. (Wet Sple 1789.6 g)
	(Dry Sple 1783.1 g)
Feed Rate:	192.1 kg/h of dry ore. (Moisture 0.36 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 1,157 kg in 6.00 hr
	Sample 386 kg in 2.00 hr
Rod Mill Discharge:	1,692 g/L (57 % Sol at Solid SG of 3.54)
	34.7 % plus 48 mesh
	45.6 % minus 100 mesh
Input Power:	33.82 for 3 disc revolutions
	1.15 kW (95% drive efficiency)
Average Power:	1.09 kW Gross
	0.47 kW No Load
	0.62 kW Net
Net Power Usage:	3.22 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,143 microns
K80 Product:	472 microns
Work Index (metric):	10.5

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 212 % circ. load)
Feed Rate:	407.2 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,274 g/L (30 % Sol at SG 3.54)
Ball Mill Discharge:	1,844 g/L (64 % Sol at SG 3.54)
	52.7 % plus 48 mesh
	20.0 % minus 100 mesh
Input Power:	33.36 for 3 disc revolutions
	1.17 kW (95% drive efficiency)
Average Power:	1.11 kW Gross
	0.52 kW No Load
	0.58 kW Net
Net Power Usage:	1.44 kWh/tonne of screen oversize.
K80 Feed:	472 microns
K80 Product:	153 microns
Work Index (metric):	4.1

3.1.3. Overall Mill Report:

Net Power Usage:	4.65 kWh/t
K80 Feed:	4,143 microns
K80 Product:	153 microns
Work Index (metric):	7.1
Screen Undersize:	78.5 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	4,143	21.5
Rod Mill Discharge	472	45.6
Ball Mill Feed	674	6.4
Ball Mill Discharge	579	20.0
Screen Feed	537	29.1
Screen Undersize	153	78.5
Prim Rghr Conc	90	91.6
Sec Rghr Conc	81	92.1
Sec Rghr Tail	176	71.6
Scavenger Conc	195	64.5
Scavenger Tail	165	75.3

3.2. Reagent Additions:

Average Feed Rate: 0.192 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	NaIX	2.0%	7.1	44.3
	DF-250	2.0%	6.3	39.4
Scavenger 1 Feed	NaIX	2.0%	7.3	45.6
	DF-250	2.0%	2.0	12.5
	CuSO4	2.0%	6.0	37.5
Scavenger 2 Feed	NaIX	2.0%	5.4	33.7
	DF-250	2.0%	4.0	25.0
Total	**NaIX**		19.8	**123.7**
	DF-250		12.3	**76.8**
	CuSO4		6.0	**37.5**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,692			3.54
Ball Mill Discharge	1,844			
Screen Feed	1,500			
Screen Undersize	1,274	9.1	24.0	
Scavenger 1 Feed	1,230	8.4		
Scavenger 2 Tail	1,310			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	--	--	--	--
Primary Rougher	56	192	1.27	8.4	6.7
Secondary Rougher	28	170	1.25	8.1	3.4
Scavenger	336	167	1.23	8.7	38.7
Total	420				48.8

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 166%** **From BILCO 212%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.47	0.68	11.1	1.46	0.68	10.95	192.1	100.00
Rod Mill Discharge	1.48	0.68	11.4	1.46	0.68	10.95	192.1	100.00
Ball Mill Feed	0.52	0.35	6.28	0.50	0.33	5.83	407.2	211.94
Ball Mill Discharge	0.50	0.32	5.77	0.50	0.33	5.83	407.2	211.94
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Screen Feed	0.77	0.44	7.09	0.81	0.44	7.50	599.3	311.94
Screen Undersize	1.43	0.71	10.70	1.46	0.68	10.95	192.1	100.00
Prim Rghr Conc	6.62	4.82	32.9	6.49	4.91	32.9	22.4	11.67
Prim Rghr Tail	0.82	0.12	8.97	0.80	0.12	8.05	169.7	88.33
Sec Rghr Conc	3.98	1.26	27.7	3.99	1.26	27.9	2.5	1.30
Sec Rghr Tail	0.77	0.10	8.70	0.75	0.107	7.75	167.2	87.03
Scavenger Conc	1.90	0.26	20.2	1.95	0.242	23.33	51.3	26.69
Scavenger Tail	0.22	0.048	0.85	0.22	0.047	0.86	115.9	60.35

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.46	0.68	10.9	3.57	22.7	1.98	6.4
Combined Conc	39.7	3.35	1.65	26.3	8.13	55.0	4.78	6.8
Final Tail	60.3	0.22	0.05	0.86	0.58	1.6	0.14	2.7
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	1.46	0.68	10.95	3.57	22.7	1.98	6.4
Prim Rghr Conc	11.7	6.49	4.91	32.9	16.47	56.1	14.24	3.4
Prim Rghr Tail	88.3	0.80	0.12	8.05	1.87	18.3	0.36	9.8
Sec Rghr Feed	88.3	0.80	0.12	8.05	1.87	18.3	0.36	9.8
Sec Rghr Conc	1.3	3.99	1.26	27.9	9.84	58.7	3.64	6.0
Sec Rghr Tail	87.0	0.75	0.11	7.75	1.75	17.7	0.31	10.1
Comb Rghr Feed	100.0	1.46	0.68	10.95	3.57	22.7	1.98	6.4
Comb Rghr Conc	13.0	6.24	4.54	32.4	15.81	56.4	13.18	3.6
Comb Rghr Tail	87.0	0.75	0.11	7.75	1.75	17.7	0.31	10.1
Scavenger Feed	87.0	0.75	0.11	7.75	1.75	17.7	0.31	10.1
Scavenger Conc	26.7	1.95	0.24	23.3	4.39	54.3	0.70	12.4
Scavenger Tail	60.3	0.22	0.05	0.86	0.58	1.6	0.14	2.7
Comb Mech Feed	100.0	1.46	0.68	10.95	3.57	22.7	1.98	6.4
Comb Mech Conc	39.7	3.35	1.65	26.3	8.13	55.0	4.78	6.8
Comb Mech Tail	60.3	0.22	0.05	0.86	0.58	1.6	0.14	2.7
Col + P.Rghr Feed	100.0	1.46	0.68	10.9	3.57	22.7	1.98	6.4
Col + P.Rghr Conc	11.7	6.50	4.91	32.9	16.5	56.1	14.2	3.4
Col + P.Rghr Tail	88.3	0.80	0.12	8.0	1.87	18.3	0.36	9.8

4.3. Metallurgical Balance - Distributions:

Product	Overall Wt %	Metal Distributions (%) Ni	Cu	S(T)	Mineral Distributions (%) Pn	Po	Cp	Gangue Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	39.7	90.9	95.8	95.2	90.2	95.9	95.8	17.8
Final Tail	60.3	9.1	4.2	4.8	9.8	4.1	4.2	82.2
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	11.7	51.8	84.0	35.1	53.8	28.8	84.0	2.1
Prim Rghr Tail	88.3	48.2	16.0	64.9	46.2	71.2	16.0	97.9
Sec Rghr Feed	88.3	48.2	15.9	64.9	46.1	71.2	15.9	97.9
Sec Rghr Conc	1.3	3.5	2.4	3.3	3.6	3.4	2.4	0.5
Sec Rghr Tail	87.0	44.6	13.5	61.6	42.6	67.9	13.5	97.4
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	13.0	55.3	86.4	38.4	57.4	32.1	86.4	2.7
Comb Rghr Tail	87.0	44.7	13.6	61.6	42.6	67.9	13.6	97.3
Scavenger Feed	87.0	44.7	13.7	61.6	42.6	67.9	13.7	97.3
Scavenger Conc	26.7	35.5	9.5	56.9	32.8	63.7	9.5	15.1
Scavenger Tail	60.3	9.1	4.2	4.8	9.8	4.1	4.2	82.2
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	39.7	90.9	95.8	95.2	90.2	95.9	95.8	17.8
Comb Mech Tail	60.3	9.1	4.2	4.8	9.8	4.1	4.2	82.2
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	11.7	51.8	84.1	35.1	53.9	28.8	84.1	2.1
Col + P.Rghr Tail	88.3	48.2	15.9	64.9	46.1	71.2	15.9	97.9

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	39.7	90.9	95.8	95.2	90.2	95.9	95.8	17.8
Final Tail	60.3	9.1	4.2	4.8	9.8	4.1	4.2	82.2
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	11.7	51.8	84.0	35.1	53.8	28.8	84.0	2.1
Prim Rghr Tail	88.3	48.2	16.0	64.9	46.2	71.2	16.0	97.9
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	1.5	7.3	15.0	5.1	7.8	4.7	15.0	0.5
Sec Rghr Tail	98.5	92.7	85.0	94.9	92.2	95.3	85.0	99.5
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	13.0	55.3	86.4	38.4	57.4	32.1	86.4	2.7
Comb Rghr Tail	87.0	44.7	13.6	61.6	42.6	67.9	13.6	97.3
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	30.7	79.5	69.3	92.3	77.0	93.9	69.3	15.5
Scavenger Tail	69.3	20.5	30.7	7.7	23.0	6.1	30.7	84.5
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	39.7	90.9	95.8	95.2	90.2	95.9	95.8	17.8
Comb Mech Tail	60.3	9.1	4.2	4.8	9.8	4.1	4.2	82.2
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	11.7	51.8	84.1	35.1	53.9	28.8	84.1	2.1
Col + P.Rghr Tail	88.3	48.2	15.9	64.9	46.1	71.2	15.9	97.9

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	80.0	14.2	14.2	85.8
6	3,327	78.4	14.0	28.2	71.8
8	2,362	55.7	9.9	38.1	61.9
10	1,651	50.1	8.9	47.0	53.0
14	1,168	37.7	6.7	53.7	46.3
20	833	27.8	4.9	58.7	41.3
28	589	26.3	4.7	63.4	36.6
35	417	23.7	4.2	67.6	32.4
48	295	20.8	3.7	71.3	28.7
65	208	20.2	3.6	74.9	25.1
100	147	20.5	3.6	78.5	21.5
150	104	18.0	3.2	81.8	18.2
200	74	16.7	3.0	84.7	15.3
270	53	17.0	3.0	87.8	12.2
400	37	10.1	1.8	89.5	10.5
Pan	-37	58.7	10.5	100.0	-
Total	-	**561.7**	**100.0**	-	-
K80	**4,143**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.6	0.3	0.3	99.7
14	1,168	2.7	1.2	1.5	98.5
20	833	7.4	3.4	4.9	95.1
28	589	16.4	7.6	12.5	87.5
35	417	25.0	11.5	24.0	76.0
48	295	23.3	10.7	34.7	65.3
65	208	21.8	10.0	44.8	55.2
100	147	21.0	9.7	54.4	45.6
150	104	16.7	7.7	62.1	37.9
200	74	14.5	6.7	68.8	31.2
270	53	13.9	6.4	75.2	24.8
400	37	10.4	4.8	80.0	20.0
Pan	-37	43.5	20.0	100.0	-
Total	-	**217.2**	**100.0**	-	-
K80	**472**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	5.9	2.0	2.0	98.0
14	1,168	11.1	3.8	5.8	94.2
20	833	19.6	6.7	12.4	87.6
28	589	35.3	12.0	24.4	75.6
35	417	57.2	19.4	43.8	56.2
48	295	71.1	24.1	67.9	32.1
65	208	56.5	19.2	87.1	12.9
100	147	19.0	6.4	93.6	6.4
150	104	6.7	2.3	95.8	4.2
200	74	3.0	1.0	96.8	3.2
270	53	1.5	0.5	97.4	2.6
400	37	0.8	0.3	97.6	2.4
Pan	-37	7.0	2.4	100.0	-
Total	-	**294.7**	**100.0**	-	-
K80	**674**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.4	2.4	2.4	97.6
14	1,168	10.3	3.8	6.1	93.9
20	833	14.3	5.3	11.4	88.6
28	589	22.3	8.2	19.6	80.4
35	417	38.7	14.2	33.8	66.2
48	295	51.3	18.9	52.7	47.3
65	208	48.3	17.8	70.4	29.6
100	147	26.1	9.6	80.0	20.0
150	104	13.4	4.9	85.0	15.0
200	74	8.5	3.1	88.1	11.9
270	53	6.0	2.2	90.3	9.7
400	37	4.0	1.5	91.8	8.2
Pan	-37	22.4	8.2	100.0	-
Total	-	**272.0**	**100.0**	-	-
K80	**579**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.9	1.4	1.4	98.6
14	1,168	9.2	2.7	4.1	95.9
20	833	15.5	4.5	8.5	91.5
28	589	27.8	8.0	16.5	83.5
35	417	45.8	13.2	29.7	70.3
48	295	55.7	16.1	45.8	54.2
65	208	53.8	15.5	61.3	38.7
100	147	33.1	9.5	70.9	29.1
150	104	21.3	6.1	77.0	23.0
200	74	16.1	4.6	81.6	18.4
270	53	12.1	3.5	85.1	14.9
400	37	9.2	2.7	87.8	12.2
Pan	-37	42.4	12.2	100.0	-
Total	-	**346.9**	**100.0**	-	-
K80	**537**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	12.2	7.7	7.7	92.3
100	147	21.9	13.8	21.5	78.5
150	104	19.6	12.4	33.8	66.2
200	74	18.3	11.5	45.4	54.6
270	53	15.9	10.0	55.4	44.6
400	37	12.6	7.9	63.3	36.7
Pan	-37	58.2	36.7	100.0	-
Total	-	**158.7**	**100.0**	-	-
K80	**152.6**				

Test No. PP-29

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.5	2.3	2.3	97.7
100	147	9.1	6.1	8.4	91.6
150	104	11.5	7.7	16.0	84.0
200	74	14.3	9.5	25.5	74.5
270	53	16.1	10.7	36.3	63.7
400	37	18.4	12.2	48.5	51.5
Pan	-37	77.4	51.5	100.0	-
Total	-	**150.3**	**100.0**	-	-
K80	**90.1**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.9	2.8	2.8	97.2
100	147	5.4	5.2	7.9	92.1
150	104	6.3	6.0	14.0	86.0
200	74	7.9	7.6	21.5	78.5
270	53	11.8	11.3	32.8	67.2
400	37	11.7	11.2	44.0	56.0
Pan	-37	58.6	56.0	100.0	-
Total	-	**104.6**	**100.0**	-	-
K80	**80.8**				

Secondary Rougher Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	18.9	11.1	11.1	88.9
100	147	29.5	17.3	28.4	71.6
150	104	23.8	14.0	42.3	57.7
200	74	20.0	11.7	54.0	46.0
270	53	16.2	9.5	63.5	36.5
400	37	11.1	6.5	70.0	30.0
Pan	-37	51.1	30.0	100.0	-
Total	-	**170.6**	**100.0**	-	-
K80	**176.0**				

Scavenger Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	11.6	14.9	14.9	85.1
100	147	16.1	20.6	35.5	64.5
150	104	9.7	12.4	47.9	52.1
200	74	8.2	10.5	58.5	41.5
270	53	6.5	8.3	66.8	33.2
400	37	4.0	5.1	71.9	28.1
Pan	-37	21.9	28.1	100.0	-
Total	-	**78.0**	**100.0**	-	-
K80	**195.2**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	13.7	9.1	9.1	90.9
100	147	23.3	15.5	24.7	75.3
150	104	20.3	13.5	38.2	61.8
200	74	17.2	11.5	49.7	50.3
270	53	13.8	9.2	58.9	41.1
400	37	9.5	6.3	65.2	34.8
Pan	-37	52.1	34.8	100.0	-
Total	-	**149.9**	**100.0**	-	-
K80	**164.6**				

Test No. PP-29

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 μm aperture)

C L R
166%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	34.7	52.7	67.9	0.0
-48+100	19.7	27.4	25.6	21.5
-100+200	14.4	8.1	3.3	23.9
-200+400	11.2	3.7	0.8	18.0
-400	20.0	8.2	2.4	36.7

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	228 %	47.2	107 %
-48+100	103 %	23.6	24 %
-100+200	200 %	10.2	20 %
-200+400	234 %	5.9	14 %
-400	284 %	13.1	37 %
Total		100.0	**166 %**

1. **Purpose:** To duplicate the conditions of test PP-29.

2. **Procedure:** All process units started with the exception of the unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		81.6 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.37	0.66	3.34	1.91	6.29
Unit Column	Grade	--	--	--	--	--
	Recov	--	--	--	--	--
Primary Rougher	Grade	6.46	4.96	16.57	14.38	2.76
	Recov	52.2	83.1	54.8	83.1	3.50
Secondary Rougher	Grade	3.83	1.18	9.57	3.43	5.30
	Recov	5.4	3.5	5.6	3.5	0.95
Scavenger	Grade	1.83	0.22	4.00	0.65	14.5
	Recov	32.1	8.1	28.8	8.1	12.13
Overall Circuit	Grade	3.32	1.69	8.04	4.89	6.71
	Recov	89.7	94.7	89.1	94.7	16.58

Metallurgical results were very similar to test PP-29.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	195.8 kg/h of -1/4 inch feed. (Wet Sple 1450.9 g)
	(Dry Sple 1430.0 g)
Feed Rate:	193.0 kg/h of dry ore. (Moisture 1.44 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 1,224 kg in 6.25 hr
	Sample 392 kg in 2.00 hr
Rod Mill Discharge:	1,702 g/L (59 % Sol at Solid SG of 3.39)
	39.5 % plus 48 mesh
	42.9 % minus 100 mesh
Input Power:	33.78 for 3 disc revolutions
	1.15 kW (95% drive efficiency)
Average Power:	1.09 kW Gross
	0.47 kW No Load
	0.62 kW Net
Net Power Usage:	3.21 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,140 microns
K80 Product:	546 microns
Work Index (metric):	11.8

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 147 % circ. load)
Feed Rate:	283.0 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,262 g/L (29 % Sol at S 3.39)
Ball Mill Discharge:	1,778 g/L (62 % Sol at S 3.39)
	50.9 % plus 48 mesh
	20.1 % minus 100 mesh
Input Power:	34.41 for 3 disc revolutions
	1.13 kW (95% drive efficiency)
Average Power:	1.07 kW Gross
	0.52 kW No Load
	0.55 kW Net
Net Power Usage:	1.95 kWh/tonne of screen oversize.
K80 Feed:	546 microns
K80 Product:	140 microns
Work Index (metric):	4.7

3.1.3. Overall Mill Report:

Net Power Usage:	5.15 kWh/t
K80 Feed:	4,140 microns
K80 Product:	140 microns
Work Index (metric):	7.5
Screen Undersize:	81.6 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,140	20.4
Rod Mill Discharge	546	42.9
Ball Mill Feed	656	6.6
Ball Mill Discharge	533	20.1
Screen Feed	506	30.0
Screen Undersize	140	81.6
Prim Rghr Conc	95	90.8
Sec Rghr Conc	83	91.6
Sec Rghr Tail	--	--
Scavenger Conc	210	53.8
Scavenger Tail	161	76.5

3.2. Reagent Additions:

Average Feed Rate: 0.193 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	NaIX	2.0%	7.3	45.4
	DF-250	2.0%	6.6	41.0
Scavenger 1 Feed	NaIX	2.0%	7.0	43.5
	DF-250	2.0%	1.9	11.8
	CuSO4	2.0%	6.2	38.5
Scavenger 2 Feed	NaIX	2.0%	5.3	33.0
	DF-250	2.0%	4.1	25.5
Total	**NaIX**		19.6	**121.9**
	DF-250		12.6	**78.3**
	CuSO4		6.2	**38.5**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,702			3.39
Ball Mill Discharge	1,778			
Screen Feed	1,556			
Screen Undersize	1,262	9.3	24.0	
Scavenger 1 Feed	1,225	8.6		
Scavenger 2 Tail	1,320			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41				
Primary Rougher	56	193	1.26	8.7	6.5
Secondary Rougher	28	172	1.23	8.8	3.2
Scavenger	336	168	1.23	8.8	38.3
Total	420				48.0

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 484%** **From BILCO 147%**

Product	Direct Assays			Adjusted Assays			Mass Flow kg/h	Mass % BILCO
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)		
Rod Mill Feed	1.24	0.63	9.61	1.37	0.66	10.15	193.0	100.00
Rod Mill Discharge	1.45	0.67	11.0	1.37	0.66	10.15	193.0	100.00
Ball Mill Feed	0.50	0.34	6.28	0.52	0.35	6.41	283.0	146.64
Ball Mill Discharge	0.52	0.36	6.52	0.52	0.35	6.41	283.0	146.64
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Screen Feed	0.88	0.46	8.03	0.86	0.47	7.93	476.1	246.64
Screen Undersize	1.48	0.79	10.4	1.37	0.66	10.15	193.0	100.00
Prim Rghr Conc	6.76	4.78	28.9	6.46	4.96	28.8	21.3	11.03
Prim Rghr Tail	0.78	0.10	8.57	0.73	0.13	7.83	171.7	88.97
Sec Rghr Conc	3.82	1.19	24.3	3.83	1.18	24.6	3.7	1.93
Sec Rghr Tail	0.68	0.095	8.37	0.67	0.102	7.46	168.0	87.04
Scavenger Conc	1.78	0.240	21.8	1.83	0.223	24.66	46.3	23.99
Scavenger Tail	0.22	0.058	0.90	0.22	0.055	0.91	121.7	63.05

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite % Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite % Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite % Cp = (2.90 x %Cu)
Gangue % Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.37	0.66	10.1	3.34	21.0	1.91	6.3
Combined Conc	37.0	3.32	1.69	25.9	8.04	54.0	4.89	6.7
Final Tail	63.0	0.22	0.06	0.91	0.58	1.7	0.16	2.9
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	1.37	0.66	10.15	3.34	21.0	1.91	6.3
Prim Rghr Conc	11.0	6.46	4.96	28.8	16.57	45.7	14.38	2.8
Prim Rghr Tail	89.0	0.73	0.13	7.83	1.70	17.9	0.36	10.6
Sec Rghr Feed	89.0	0.73	0.13	7.83	1.70	17.9	0.36	10.6
Sec Rghr Conc	1.9	3.83	1.18	24.6	9.57	50.7	3.43	5.3
Sec Rghr Tail	87.0	0.67	0.10	7.46	1.52	17.2	0.30	11.3
Comb Rghr Feed	100.0	1.37	0.66	10.15	3.34	21.0	1.91	6.3
Comb Rghr Conc	13.0	6.07	4.39	28.2	15.52	46.4	12.74	3.0
Comb Rghr Tail	87.0	0.67	0.10	7.46	1.52	17.2	0.30	11.3
Scavenger Feed	87.0	0.67	0.10	7.46	1.52	17.2	0.30	11.3
Scavenger Conc	24.0	1.83	0.22	24.7	4.00	58.0	0.65	14.5
Scavenger Tail	63.0	0.22	0.06	0.91	0.58	1.7	0.16	2.9
Comb Mech Feed	100.0	1.37	0.66	10.15	3.34	21.0	1.91	6.3
Comb Mech Conc	37.0	3.32	1.69	25.9	8.04	54.0	4.89	6.7
Comb Mech Tail	63.0	0.22	0.06	0.91	0.58	1.7	0.16	2.9
Col + P.Rghr Feed	100.0	1.37	0.66	10.1	3.34	21.0	1.91	6.3
Col + P.Rghr Conc	11.0	6.45	4.96	28.8	16.6	45.7	14.4	2.8
Col + P.Rghr Tail	89.0	0.73	0.13	7.8	1.70	17.9	0.36	10.6

4.3. Metallurgical Balance - Distributions:

Product	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	37.0	89.7	94.7	94.3	89.1	95.0	94.7	16.6
Final Tail	63.0	10.3	5.3	5.7	10.9	5.0	5.3	83.4
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	11.0	52.2	83.1	31.3	54.8	24.0	83.1	3.5
Prim Rghr Tail	89.0	47.8	16.9	68.7	45.2	76.0	16.9	96.5
Sec Rghr Feed	89.0	47.8	16.9	68.7	45.3	76.0	16.9	96.5
Sec Rghr Conc	1.9	5.4	3.5	4.7	5.6	4.7	3.5	1.0
Sec Rghr Tail	87.0	42.4	13.4	64.0	39.7	71.3	13.4	95.5
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	13.0	57.6	86.6	36.0	60.3	28.7	86.6	4.4
Comb Rghr Tail	87.0	42.4	13.4	64.0	39.7	71.3	13.4	95.6
Scavenger Feed	87.0	42.4	13.5	64.0	39.7	71.3	13.5	95.6
Scavenger Conc	24.0	32.1	8.1	58.3	28.8	66.3	8.1	12.1
Scavenger Tail	63.0	10.3	5.4	5.7	10.9	5.0	5.4	83.4
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	37.0	89.7	94.7	94.3	89.1	95.0	94.7	16.6
Comb Mech Tail	63.0	10.3	5.3	5.7	10.9	5.0	5.3	83.4
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	11.0	52.2	83.1	31.3	54.7	24.0	83.1	3.5
Col + P.Rghr Tail	89.0	47.8	16.9	68.7	45.3	76.0	16.9	96.5

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	37.0	89.7	94.7	94.3	89.1	95.0	94.7	16.6
Final Tail	63.0	10.3	5.3	5.7	10.9	5.0	5.3	83.4
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	11.0	52.2	83.1	31.3	54.8	24.0	83.1	3.5
Prim Rghr Tail	89.0	47.8	16.9	68.7	45.2	76.0	16.9	96.5
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	2.2	11.4	20.6	6.8	12.3	6.1	20.6	1.0
Sec Rghr Tail	97.8	88.6	79.4	93.2	87.7	93.9	79.4	99.0
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	13.0	57.6	86.6	36.0	60.3	28.7	86.6	4.4
Comb Rghr Tail	87.0	42.4	13.4	64.0	39.7	71.3	13.4	95.6
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	27.6	75.8	60.3	91.1	72.5	93.0	60.3	12.7
Scavenger Tail	72.4	24.2	39.7	8.9	27.5	7.0	39.7	87.3
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	37.0	89.7	94.7	94.3	89.1	95.0	94.7	16.6
Comb Mech Tail	63.0	10.3	5.3	5.7	10.9	5.0	5.3	83.4
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	11.0	52.2	83.1	31.3	54.7	24.0	83.1	3.5
Col + P.Rghr Tail	89.0	47.8	16.9	68.7	45.3	76.0	16.9	96.5

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	68.4	13.8	13.8	86.2
6	3,327	72.9	14.7	28.6	71.4
8	2,362	57.7	11.7	40.3	59.7
10	1,651	46.2	9.3	49.6	50.4
14	1,168	33.2	6.7	56.3	43.7
20	833	23.9	4.8	61.1	38.9
28	589	21.6	4.4	65.5	34.5
35	417	19.7	4.0	69.5	30.5
48	295	16.1	3.3	72.8	27.2
65	208	17.0	3.4	76.2	23.8
100	147	16.6	3.4	79.6	20.4
150	104	14.3	2.9	82.4	17.6
200	74	14.6	3.0	85.4	14.6
270	53	14.6	3.0	88.3	11.7
400	37	9.1	1.8	90.2	9.8
Pan	-37	48.5	9.8	100.0	-
Total	-	**494.4**	**100.0**	-	-
K80	**4,140**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.9	0.4	0.4	99.6
14	1,168	4.2	1.8	2.1	97.9
20	833	11.7	4.9	7.1	92.9
28	589	24.0	10.1	17.2	82.8
35	417	28.2	11.9	29.0	71.0
48	295	24.9	10.5	39.5	60.5
65	208	21.5	9.0	48.6	51.4
100	147	20.2	8.5	57.1	42.9
150	104	16.3	6.9	63.9	36.1
200	74	14.4	6.1	70.0	30.0
270	53	12.9	5.4	75.4	24.6
400	37	9.8	4.1	79.5	20.5
Pan	-37	48.6	20.5	100.0	-
Total	-	**237.6**	**100.0**	-	-
K80	**546**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	5.3	1.2	1.2	98.8
14	1,168	13.9	3.2	4.5	95.5
20	833	28.2	6.6	11.0	89.0
28	589	54.3	12.6	23.6	76.4
35	417	83.8	19.5	43.1	56.9
48	295	109.4	25.4	68.5	31.5
65	208	81.4	18.9	87.5	12.5
100	147	25.5	5.9	93.4	6.6
150	104	9.4	2.2	95.6	4.4
200	74	4.3	1.0	96.6	3.4
270	53	2.2	0.5	97.1	2.9
400	37	1.3	0.3	97.4	2.6
Pan	-37	11.2	2.6	100.0	-
Total	-	**430.2**	**100.0**	-	-
K80	**656**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.5	1.0	1.0	99.0
14	1,168	9.1	2.7	3.8	96.2
20	833	14.5	4.3	8.1	91.9
28	589	26.9	8.0	16.1	83.9
35	417	46.8	14.0	30.1	69.9
48	295	69.8	20.8	50.9	49.1
65	208	62.1	18.5	69.4	30.6
100	147	34.9	10.4	79.9	20.1
150	104	17.5	5.2	85.1	14.9
200	74	10.8	3.2	88.3	11.7
270	53	8.0	2.4	90.7	9.3
400	37	5.3	1.6	92.3	7.7
Pan	-37	25.9	7.7	100.0	-
Total	-	**335.1**	**100.0**	-	-
K80	**533**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.9	0.8	0.8	99.2
14	1,168	4.8	2.0	2.7	97.3
20	833	9.5	3.9	6.6	93.4
28	589	19.0	7.8	14.4	85.6
35	417	30.7	12.6	27.0	73.0
48	295	39.9	16.4	43.4	56.6
65	208	40.2	16.5	59.9	40.1
100	147	24.7	10.1	70.0	30.0
150	104	14.8	6.1	76.1	23.9
200	74	11.2	4.6	80.7	19.3
270	53	9.1	3.7	84.4	15.6
400	37	6.8	2.8	87.2	12.8
Pan	-37	31.2	12.8	100.0	-
Total	-	**243.8**	**100.0**	-	-
K80	**506**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	8.9	6.6	6.6	93.4
100	147	16.1	11.9	18.4	81.6
150	104	15.5	11.4	29.8	70.2
200	74	15.6	11.5	41.3	58.7
270	53	14.6	10.8	52.1	47.9
400	37	11.8	8.7	60.8	39.2
Pan	-37	53.2	39.2	100.0	-
Total	-	**135.7**	**100.0**	-	-
K80	**140**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.1	2.4	2.4	97.6
100	147	9.0	6.8	9.2	90.8
150	104	10.9	8.3	17.5	82.5
200	74	13.0	9.9	27.4	72.6
270	53	14.8	11.2	38.6	61.4
400	37	15.9	12.1	50.7	49.3
Pan	-37	64.9	49.3	100.0	-
Total	-	**131.6**	**100.0**	-	-
K80	**95**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.5	3.4	3.4	96.6
100	147	5.3	5.1	8.4	91.6
150	104	6.0	5.8	14.2	85.8
200	74	8.3	8.0	22.1	77.9
270	53	12.0	11.5	33.7	66.3
400	37	10.1	9.7	43.3	56.7
Pan	-37	59.1	56.7	100.0	-
Total	-	**104.3**	**100.0**	-	-
K80	**83**				

Scavenger Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	14.9	21.4	21.4	78.6
100	147	17.2	24.7	46.2	53.8
150	104	9.6	13.8	60.0	40.0
200	74	6.4	9.2	69.2	30.8
270	53	4.0	5.8	75.0	25.0
400	37	2.5	3.6	78.6	21.4
Pan	-37	14.9	21.4	100.0	-
Total	-	**69.5**	**100.0**	-	-
K80	**210**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	11.7	8.0	8.0	92.0
100	147	22.5	15.5	23.5	76.5
150	104	19.5	13.4	36.9	63.1
200	74	16.0	11.0	47.9	52.1
270	53	14.2	9.8	57.7	42.3
400	37	10.6	7.3	65.0	35.0
Pan	-37	50.9	35.0	100.0	-
Total	-	**145.4**	**100.0**	-	-
K80	**161**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 µm aperture)

C L R
146%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	39.5	50.9	68.5	0.0
-48+100	17.6	28.9	24.8	18.4
-100+200	12.9	8.4	3.2	22.9
-200+400	9.6	4.0	0.8	19.5
-400	20.5	7.7	2.6	39.2

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	224 %	47.4	106 %
-48+100	21 %	19.6	4 %
-100+200	190 %	10.0	19 %
-200+400	314 %	5.3	17 %
-400	365 %	17.7	65 %
Total		100.0	**146 %**

Test No. PP-31

1. **Purpose:** First run after delay of several months due to committments in pilot plant. The ore supply was retained in coarse state (-10 inch) until immediately prior to re-starting the pilot plant, but oxidation is likely.

2. **Procedure:** All process units started, including unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		78.4 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.55	0.62	3.84	1.80	5.57
Unit Column	Grade	5.60	5.52	14.0	16.0	4.06
	Recov	24.7	60.6	24.8	60.6	1.25
Primary Rougher	Grade	4.64	2.33	11.68	6.75	4.45
	Recov	18.9	23.6	19.2	23.6	2.55
Secondary Rougher	Grade	4.37	1.20	11.09	3.47	4.41
	Recov	4.3	2.9	4.4	2.9	0.77
Scavenger	Grade	3.12	0.26	7.22	0.75	10.6
	Recov	28.9	6.0	27.0	6.0	3.04
Overall Circuit	Grade	4.10	2.00	9.98	5.80	6.51
	Recov	76.7	93.3	75.4	93.3	7.63

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	196.4 kg/h of -1/4 inch feed. (Wet Sple 1024.5 g)
	(Dry Sple 1014.6 g)
Feed Rate:	194.5 kg/h of dry ore. (Moisture 0.97 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 1,031 kg in 5.25 hr
	Sample 393 kg in 2.00 hr
Rod Mill Discharge:	1,473 g/L (46 % Sol at Solid SG of 3.39)
	41.8 % plus 48 mesh
	40.7 % minus 100 mesh
Input Power:	36.51 for 3 disc revolutions
	1.06 kW (95% drive efficiency)
Average Power:	1.01 kW Gross
	0.47 kW No Load
	0.54 kW Net
Net Power Usage:	2.76 kWh/tonne of -1/4 inch feed.
K80 Feed:	3,840 microns
K80 Product:	584 microns
Work Index (metric):	10.9

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 683 % circ. load)
Feed Rate:	1328.9 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,160 g/L (20 % Sol at S' 3.39)
Ball Mill Discharge:	1,678 g/L (57 % Sol at S' 3.39)
	76.4 % plus 48 mesh
	5.9 % minus 100 mesh
Input Power:	27.80 for 3 disc revolutions
	1.40 kW (95% drive efficiency)
Average Power:	1.33 kW Gross
	0.52 kW No Load
	0.81 kW Net
Net Power Usage:	0.61 kWh/tonne of screen oversize.
K80 Feed:	584 microns
K80 Product:	153 microns
Work Index (metric):	1.5

3.1.3. Overall Mill Report:

Net Power Usage:	3.38 kWh/t
K80 Feed:	3,840 microns
K80 Product:	153 microns
Work Index (metric):	5.2
Screen Undersize:	78.4 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	3,840	21.4
Rod Mill Discharge	584	40.7
Ball Mill Feed	713	3.3
Ball Mill Discharge	694	5.9
Column Feed	656	19.0
Column Conc	90	92.6
Screen Feed	673	14.3
Screen Undersize	153	78.4
Prim Rghr Conc	159	77.6
Sec Rghr Conc	71	90.6
Scavenger Tail	122	87.7

3.2. Reagent Additions:

Average Feed Rate: 0.194 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Column Feed	NaIX	2.0%	3.1	19.2
	DF-250	2.0%	5.0	30.9
Rougher Feed	NaIX	2.0%	5.3	32.8
	DF-250	2.0%	2.6	16.1
Scavenger 1 Feed	NaIX	2.0%	7.0	43.3
	DF-250	2.0%	2.0	12.4
	CuSO4	2.0%	5.9	36.5
Scavenger 2 Feed	NaIX	2.0%	5.2	32.2
	DF-250	2.0%	4.1	25.4
Total	**NaIX**		20.6	**127.5**
	DF-250		13.7	**84.8**
	CuSO4		5.9	**36.5**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,473			3.40
Ball Mill Discharge	1,678			
Screen Feed	1,545	9.83		
Screen Undersize	1,160	9.44	27.0	
Scavenger 1 Feed	1,095	8.52		
Scavenger 2 Tail	1,135			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	1,519	1.545	32.8	1.3
Primary Rougher	56	181	1.16	13.3	4.2
Secondary Rougher	28	169	1.10	19.8	1.4
Scavenger	336	166	1.14	14.4	23.3
Total	420				28.9

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 757%** **From BILCO 683%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.52	0.63	11.0	1.55	0.62	10.4	193.9	100.00
Rod Mill Discharge	1.46	0.65	10.7	1.55	0.62	10.4	193.9	100.00
Ball Mill Feed	0.56	0.33	7.07	0.57	0.34	6.73	1,325.0	683.16
Ball Mill Discharge	0.52	0.32	6.33	0.57	0.34	6.73	1,325.0	683.16
Unit Column Feed	0.84	0.46	7.48	0.69	0.38	7.20	1,518.9	783.16
Unit Column Conc	5.77	5.27	33.2	5.60	5.52	32.9	13.2	6.82
Screen Feed	0.65	0.33	6.72	0.65	0.33	6.97	1,505.7	776.34
Screen Undersize	1.28	0.25	8.6	1.25	0.26	8.78	180.7	93.18
Prim Rghr Conc	4.67	2.34	26.5	4.64	2.33	27.0	12.2	6.29
Prim Rghr Tail	1.03	0.10	8.12	1.01	0.11	7.46	168.5	86.88
Sec Rghr Conc	4.34	1.22	23.7	4.37	1.20	24.4	3.0	1.53
Sec Rghr Tail	1.03	0.100	9.33	0.95	0.093	7.16	165.5	85.35
Scavenger Conc	3.04	0.270	28.8	3.12	0.259	33.1	27.8	14.33
Scavenger Tail	0.49	0.061	1.81	0.51	0.059	1.93	137.7	71.02

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

	Overall	Metal Assays			Mineral Assays			Ratio
Product	Wt %	% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.55	0.62	10.4	3.84	21.4	1.80	5.6
Combined Conc	29.0	4.10	2.00	31.3	9.98	65.0	5.80	6.5
Final Tail	71.0	0.51	0.06	1.93	1.33	3.6	0.17	2.7
Unit Column Feed	783.2	0.69	0.38	7.20	1.60	15.8	1.10	9.9
Unit Column Conc	6.8	5.60	5.52	32.93	13.96	56.7	16.00	4.1
Unit Column Tail	776.3	0.65	0.33	6.97	1.49	15.4	0.97	10.4
Prim Rghr Feed	93.2	1.25	0.26	8.78	3.10	18.8	0.76	6.1
Prim Rghr Conc	6.3	4.64	2.33	27.0	11.68	52.0	6.75	4.5
Prim Rghr Tail	86.9	1.01	0.11	7.46	2.48	16.4	0.32	6.6
Sec Rghr Feed	86.9	1.01	0.11	7.46	2.48	16.4	0.32	6.6
Sec Rghr Conc	1.5	4.37	1.20	24.4	11.09	48.9	3.47	4.4
Sec Rghr Tail	85.4	0.95	0.09	7.16	2.32	15.8	0.27	6.8
Comb Rghr Feed	93.2	1.25	0.26	8.78	3.10	18.8	0.76	6.1
Comb Rghr Conc	7.8	4.59	2.11	26.5	11.57	51.4	6.11	4.4
Comb Rghr Tail	85.4	0.95	0.09	7.16	2.32	15.8	0.27	6.8
Scavenger Feed	85.4	0.95	0.09	7.16	2.32	15.8	0.27	6.8
Scavenger Conc	14.3	3.12	0.26	33.1	7.22	76.6	0.75	10.6
Scavenger Tail	71.0	0.51	0.06	1.93	1.33	3.6	0.17	2.7
Comb Mech Feed	93.2	1.25	0.26	8.78	3.10	18.8	0.76	6.1
Comb Mech Conc	22.2	3.64	0.91	30.7	8.76	67.6	2.65	7.7
Comb Mech Tail	71.0	0.51	0.06	1.93	1.33	3.6	0.17	2.7
Col + P.Rghr Feed	100.0	1.55	0.62	10.4	3.84	21.4	1.80	5.6
Col + P.Rghr Conc	13.1	5.14	3.99	30.1	12.9	54.4	11.6	4.2
Col + P.Rghr Tail	86.9	1.01	0.11	7.5	2.48	16.4	0.32	6.6

4.3. Metallurgical Balance - Distributions:

Product	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	29.0	76.7	93.3	86.9	75.4	88.1	93.3	7.6
Final Tail	71.0	23.3	6.7	13.1	24.6	11.9	6.7	92.4
Unit Column Feed	783.2	350.6	476.7	540.6	326.4	577.4	476.7	875.0
Unit Column Conc	6.8	24.7	60.6	21.5	24.8	18.1	60.6	1.2
Unit Column Tail	776.3	325.9	416.1	519.1	301.6	559.4	416.1	873.8
Prim Rghr Feed	93.2	75.3	39.3	78.5	75.2	81.9	39.3	98.8
Prim Rghr Conc	6.3	18.9	23.6	16.3	19.2	15.3	23.6	2.5
Prim Rghr Tail	86.9	56.4	15.7	62.2	56.0	66.6	15.7	96.2
Sec Rghr Feed	86.9	56.5	15.7	62.2	56.1	66.6	15.7	96.2
Sec Rghr Conc	1.5	4.3	2.9	3.6	4.4	3.5	2.9	0.8
Sec Rghr Tail	85.4	52.1	12.7	58.6	51.6	63.1	12.7	95.4
Comb Rghr Feed	93.2	75.3	39.3	78.5	75.2	81.9	39.3	98.8
Comb Rghr Conc	7.8	23.2	26.5	19.9	23.6	18.8	26.5	3.3
Comb Rghr Tail	85.4	52.1	12.8	58.6	51.6	63.1	12.8	95.4
Scavenger Feed	85.4	52.1	12.8	58.6	51.6	63.1	12.8	95.4
Scavenger Conc	14.3	28.9	6.0	45.5	27.0	51.3	6.0	3.0
Scavenger Tail	71.0	23.2	6.8	13.1	24.6	11.8	6.8	92.4
Comb Mech Feed	93.2	75.3	39.3	78.5	75.2	81.9	39.3	98.8
Comb Mech Conc	22.2	52.0	32.6	65.3	50.6	70.0	32.6	6.4
Comb Mech Tail	71.0	23.3	6.7	13.1	24.6	11.9	6.7	92.4
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	13.1	43.5	84.3	37.8	43.9	33.4	84.3	3.8
Col + P.Rghr Tail	86.9	56.5	15.7	62.2	56.1	66.6	15.7	96.2

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	29.0	76.7	93.3	86.9	75.4	88.1	93.3	7.6
Final Tail	71.0	23.3	6.7	13.1	24.6	11.9	6.7	92.4
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	0.9	7.0	12.7	4.0	7.6	3.1	12.7	0.1
Unit Column Tail	99.1	93.0	87.3	96.0	92.4	96.9	87.3	99.9
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	6.8	25.1	60.0	20.8	25.5	18.7	60.0	2.6
Prim Rghr Tail	93.2	74.9	40.0	79.2	74.5	81.3	40.0	97.4
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	1.8	7.7	18.8	5.8	7.9	5.3	18.8	0.8
Sec Rghr Tail	98.2	92.3	81.2	94.2	92.1	94.7	81.2	99.2
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	8.4	30.8	67.5	25.3	31.4	23.0	67.5	3.4
Comb Rghr Tail	91.6	69.2	32.5	74.7	68.6	77.0	32.5	96.6
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	16.8	55.4	46.8	77.7	52.3	81.3	46.8	3.2
Scavenger Tail	83.2	44.6	53.2	22.3	47.7	18.7	53.2	96.8
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	23.8	69.1	82.8	83.2	67.3	85.5	82.8	6.5
Comb Mech Tail	76.2	30.9	17.2	16.8	32.7	14.5	17.2	93.5
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	13.1	43.5	84.3	37.8	43.9	33.4	84.3	3.8
Col + P.Rghr Tail	86.9	56.5	15.7	62.2	56.1	66.6	15.7	96.2

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4.699	61.7	12.5	12.5	87.5
6	3,327	63.9	12.9	25.4	74.6
8	2,362	44.4	9.0	34.4	65.6
10	1,651	50.9	10.3	44.7	55.3
14	1,168	33.8	6.8	51.5	48.5
20	833	25.9	5.2	56.7	43.3
28	589	24.7	5.0	61.7	38.3
35	417	23.5	4.8	66.5	33.5
48	295	19.7	4.0	70.5	29.5
65	208	19.5	3.9	74.4	25.6
100	147	20.7	4.2	78.6	21.4
150	104	17.4	3.5	82.1	17.9
200	74	15.8	3.2	85.3	14.7
270	53	14.6	3.0	88.3	11.7
400	37	10.8	2.2	90.5	9.5
Pan	-37	47.2	9.5	100.0	-
Total	-	**494.5**	**100.0**	-	-
K80	**3,840**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.8	0.6	0.6	99.4
14	1,168	6.8	2.4	3.1	96.9
20	833	16.9	6.0	9.1	90.9
28	589	29.4	10.5	19.6	80.4
35	417	34.3	12.3	31.9	68.1
48	295	27.7	9.9	41.8	58.3
65	208	25.8	9.2	51.0	49.0
100	147	23.4	8.4	59.3	40.7
150	104	19.8	7.1	66.4	33.6
200	74	17.8	6.4	72.8	27.3
270	53	15.1	5.4	78.1	21.9
400	37	12.7	4.5	82.7	17.3
Pan	-37	48.5	17.3	100.0	-
Total	-	**280.0**	**100.0**	-	-
K80	**584**				

Test No. PP-31

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.3	0.1	0.1	99.9
14	1,168	13.4	4.2	4.3	95.7
20	833	26.0	8.1	12.4	87.6
28	589	54.7	17.0	29.4	70.6
35	417	81.4	25.3	54.7	45.3
48	295	84.4	26.3	81.0	19.0
65	208	39.7	12.4	93.4	6.6
100	147	10.7	3.3	96.7	3.3
150	104	3.9	1.2	97.9	2.1
200	74	1.8	0.6	98.5	1.5
270	53	1.0	0.3	98.8	1.2
400	37	0.7	0.2	99.0	1.0
Pan	-37	3.2	1.0	100.0	-
Total	-	**321.2**	**100.0**	-	-
K80	**713**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.3	0.1	0.1	99.9
14	1,168	10.8	4.7	4.8	95.2
20	833	16.6	7.2	11.9	88.1
28	589	34.8	15.0	26.9	73.1
35	417	54.5	23.5	50.4	49.6
48	295	60.4	26.0	76.4	23.6
65	208	31.7	13.7	90.1	9.9
100	147	9.3	4.0	94.1	5.9
150	104	3.9	1.7	95.8	4.2
200	74	2.1	0.9	96.7	3.3
270	53	1.4	0.6	97.3	2.7
400	37	0.8	0.3	97.6	2.4
Pan	-37	5.5	2.4	100.0	-
Total	-	**232.1**	**100.0**	-	-
K80	**694**				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.9	0.7	0.7	99.3
14	1,168	7.4	2.8	3.5	96.5
20	833	17.4	6.5	10.0	90.0
28	589	36.8	13.8	23.8	76.2
35	417	53.3	20.0	43.7	56.3
48	295	52.5	19.7	63.4	36.6
65	208	32.2	12.1	75.4	24.6
100	147	14.9	5.6	81.0	19.0
150	104	9.1	3.4	84.4	15.6
200	74	7.7	2.9	87.3	12.7
270	53	6.6	2.5	89.8	10.2
400	37	5.2	1.9	91.7	8.3
Pan	-37	22.1	8.3	100.0	-
Total	-	**267.1**	**100.0**	-	-
K80	**656**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	4.9	3.0	3.0	97.0
100	147	7.2	4.4	7.4	92.6
150	104	12.9	7.9	15.3	84.7
200	74	18.2	11.1	26.4	73.6
270	53	21.5	13.1	39.5	60.5
400	37	20.2	12.3	51.8	48.2
Pan	-37	79.0	48.2	100.0	-
Total	-	**163.9**	**100.0**	-	-
K80	**90**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.8	0.3	0.3	99.7
14	1,168	9.6	3.6	3.9	96.1
20	833	18.6	7.0	11.0	89.0
28	589	37.2	14.1	25.1	74.9
35	417	56.4	21.4	46.4	53.6
48	295	58.1	22.0	68.4	31.6
65	208	32.2	12.2	80.6	19.4
100	147	13.3	5.0	85.7	14.3
150	104	7.4	2.8	88.5	11.5
200	74	6.0	2.3	90.8	9.2
270	53	4.8	1.8	92.6	7.4
400	37	3.6	1.4	93.9	6.1
Pan	-37	16.0	6.1	100.0	-
Total	-	**264.0**	**100.0**	-	-
K80	**673**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	12.9	9.4	9.4	90.6
100	147	16.8	12.2	21.6	78.4
150	104	14.1	10.2	31.8	68.2
200	74	14.1	10.2	42.0	58.0
270	53	12.4	9.0	51.0	49.0
400	37	10.0	7.3	58.3	41.7
Pan	-37	57.5	41.7	100.0	-
Total	-	**137.8**	**100.0**	-	-
K80	**153**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	5.2	8.5	8.5	91.5
100	147	8.5	13.9	22.4	77.6
150	104	5.3	8.7	31.1	68.9
200	74	4.3	7.0	38.1	61.9
270	53	4.7	7.7	45.8	54.2
400	37	4.5	7.4	53.2	46.8
Pan	-37	28.6	46.8	100.0	-
Total	-	**61.1**	**100.0**	-	-
K80	**159**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.1	4.3	4.3	95.7
100	147	3.7	5.1	9.4	90.6
150	104	2.9	4.0	13.5	86.5
200	74	4.1	5.7	19.2	80.8
270	53	5.7	7.9	27.1	72.9
400	37	6.1	8.5	35.6	64.4
Pan	-37	46.4	64.4	100.0	-
Total	-	**72.0**	**100.0**	-	-
K80	**71**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.9	2.4	2.4	97.6
100	147	16.2	9.9	12.3	87.7
150	104	22.2	13.6	25.9	74.1
200	74	19.3	11.8	37.7	62.3
270	53	16.6	10.2	47.9	52.1
400	37	12.3	7.5	55.4	44.6
Pan	-37	72.9	44.6	100.0	-
Total	-	**163.4**	**100.0**	-	-
K80	**122**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 µm aperture)

C L R
757%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	41.8	76.4	81.0	0.0
-48+100	17.6	17.7	15.7	21.6
-100+200	13.4	2.6	1.8	20.5
-200+400	9.9	0.9	0.5	16.3
-400	17.3	2.4	1.0	41.7

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	912 %	73.0	666 %
-48+100	202 %	17.6	36 %
-100+200	868 %	3.7	32 %
-200+400	1511 %	1.5	23 %
-400	1777 %	4.1	74 %
Total		100.0	757 %

1. Purpose: To duplicate the conditions of test PP-31.

2. Procedure: All process units started, including unit column.

2.1. Flowsheet: The flowsheet is shown in Figure 1b.

2.2. Equipment: The equipment list is shown in Table 1b.

3. Results:

Flotation Feed Size		77.8 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.40	0.64	3.44	1.85	6.23
Unit Column	Grade	7.40	4.64	19.0	13.4	2.93
	Recov	42.5	58.6	44.6	58.6	1.31
Primary Rougher	Grade	5.21	2.84	13.20	8.22	3.96
	Recov	21.6	25.8	22.3	25.8	2.07
Secondary Rougher	Grade	3.55	1.51	8.97	4.38	4.30
	Recov	2.0	1.9	2.1	1.9	0.52
Scavenger	Grade	1.70	0.25	3.55	0.72	17.8
	Recov	23.9	7.7	20.4	7.7	8.73
Overall Circuit	Grade	3.69	1.75	8.99	5.06	6.56
	Recov	90.5	94.1	90.0	94.1	12.65

A slight change in dilution water addition to the ball mill feed resulted in a significant reduction in the circulating load. The circuit was observed to be very sensitive to ball mill feed dilution.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	199.9 kg/h of -1/4 inch feed. (Wet Sple 1930.4 g)
	(Dry Sple 1898.5 g)
Feed Rate:	196.6 kg/h of dry ore. (Moisture 1.65 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 1,399 kg in 7.00 hr
	Sample 400 kg in 2.00 hr
Rod Mill Discharge:	1,575 g/L (52 % Sol at Solid SG of 3.40)
	42.4 % plus 48 mesh
	41.3 % minus 100 mesh
Input Power:	35.11 for 3 disc revolutions
	1.11 kW (95% drive efficiency)
Average Power:	1.05 kW Gross
	0.47 kW No Load
	0.58 kW Net
Net Power Usage:	2.94 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,233 microns
K80 Product:	619 microns
Work Index (metric):	11.8

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 227 % circ. load)
Feed Rate:	446.4 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,191 g/L (23 % Sol at S 3.40)
Ball Mill Discharge:	1,975 g/L (70 % Sol at S 3.40)
	76.8 % plus 48 mesh
	4.4 % minus 100 mesh
Input Power:	29.81 for 3 disc revolutions
	1.30 kW (95% drive efficiency)
Average Power:	1.24 kW Gross
	0.52 kW No Load
	0.72 kW Net
Net Power Usage:	1.60 kWh/tonne of screen oversize.
K80 Feed:	619 microns
K80 Product:	155 microns
Work Index (metric):	4.0

3.1.3. Overall Mill Report:

Net Power Usage:	4.54 kWh/t
K80 Feed:	4,233 microns
K80 Product:	155 microns
Work Index (metric):	7.0
Screen Undersize:	77.8 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,233	20.0
Rod Mill Discharge	619	41.3
Ball Mill Feed	809	4.4
Ball Mill Discharge	757	21.6
Column Feed	650	33.9
Column Conc	86	92.6
Screen Feed	776	28.6
Screen Undersize	155	77.8
Prim Rghr Conc	105	88.6
Sec Rghr Conc	62	95.0
Scavenger Tail	165	74.9

3.2. Reagent Additions:

Average Feed Rate: 0.197 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Column Feed	NaIX	2.0%	2.9	17.7
	DF-250	2.0%	4.8	29.3
Rougher Feed	NaIX	2.0%	4.9	29.9
	DF-250	2.0%	2.9	17.7
Scavenger 1 Feed	NaIX	2.0%	6.9	42.1
	DF-250	2.0%	1.9	11.6
	CuSO4	2.0%	6.0	36.6
Scavenger 2 Feed	NaIX	2.0%	4.9	29.9
	DF-250	2.0%	4.0	24.4
Total	**NaIX**		19.6	**119.7**
	DF-250		13.6	**83.0**
	CuSO4		6.0	**36.6**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,575			3.36
Ball Mill Discharge	1,975			
Screen Feed	1,550	8.5		
Screen Undersize	1,191	8.0	28.0	
Scavenger 1 Feed	1,208	7.6		
Scavenger 2 Tail	1,218			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density kg/L	Rate L/min	Time min
Unit Column	41	643	1.55	13.7	3.0
Primary Rougher	56	181	1.19	11.1	5.1
Secondary Rougher	28	169	1.20	9.9	2.8
Scavenger	336	168	1.21	9.4	35.6
Total	420				43.5

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 189%** **From BILCO 227%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.52	0.69	11.5	1.40	0.64	10.3	196.6	100.00
Rod Mill Discharge	1.38	0.66	9.5	1.40	0.64	10.3	196.6	100.00
Ball Mill Feed	0.42	0.30	5.18	0.41	0.29	5.08	446.4	227.08
Ball Mill Discharge	0.44	0.31	5.60	0.41	0.29	5.08	446.4	227.08
Unit Column Feed	0.64	0.36	6.50	0.71	0.40	6.68	642.9	327.08
Unit Column Conc	7.40	4.44	34.5	7.40	4.64	33.3	15.9	8.07
Screen Feed	0.51	0.28	5.64	0.54	0.29	6.01	627.1	319.01
Screen Undersize	0.96	0.26	9.0	0.88	0.29	8.30	180.7	91.93
Prim Rghr Conc	5.04	2.97	27.2	5.21	2.84	28.2	11.4	5.80
Prim Rghr Tail	0.59	0.10	7.20	0.58	0.11	6.96	169.3	86.13
Sec Rghr Conc	3.52	1.54	19.6	3.55	1.51	19.9	1.6	0.79
Sec Rghr Tail	0.55	0.100	7.37	0.55	0.101	6.84	167.7	85.34
Scavenger Conc	1.63	0.280	23.6	1.70	0.248	26.6	38.8	19.73
Scavenger Tail	0.20	0.063	0.89	0.20	0.057	0.90	129.0	65.60

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.40	0.64	10.3	3.44	21.4	1.85	6.2
Combined Conc	34.4	3.69	1.75	28.3	8.99	59.0	5.06	6.6
Final Tail	65.6	0.20	0.06	0.90	0.53	1.7	0.17	3.2
Unit Column Feed	327.1	0.71	0.40	6.68	1.67	14.4	1.15	8.6
Unit Column Conc	8.1	7.40	4.64	33.3	19.0	55.7	13.44	2.9
Unit Column Tail	319.0	0.54	0.29	6.01	1.23	13.3	0.84	10.8
Prim Rghr Feed	91.9	0.88	0.29	8.30	2.07	18.4	0.83	8.9
Prim Rghr Conc	5.8	5.21	2.84	28.2	13.20	52.3	8.22	4.0
Prim Rghr Tail	86.1	0.58	0.11	6.96	1.30	16.1	0.33	12.4
Sec Rghr Feed	86.1	0.58	0.11	6.96	1.30	16.1	0.33	12.4
Sec Rghr Conc	0.8	3.55	1.51	19.9	8.97	38.6	4.38	4.3
Sec Rghr Tail	85.3	0.55	0.10	6.84	1.23	15.9	0.29	12.9
Comb Rghr Feed	91.9	0.88	0.29	8.30	2.07	18.4	0.83	8.9
Comb Rghr Conc	6.6	5.01	2.68	27.2	12.69	50.7	7.76	4.0
Comb Rghr Tail	85.3	0.55	0.10	6.84	1.23	15.9	0.29	12.9
Scavenger Feed	85.3	0.55	0.10	6.84	1.23	15.9	0.29	12.9
Scavenger Conc	19.7	1.70	0.25	26.6	3.55	63.3	0.72	17.8
Scavenger Tail	65.6	0.20	0.06	0.90	0.53	1.7	0.17	3.2
Comb Mech Feed	91.9	0.88	0.29	8.30	2.07	18.4	0.83	8.9
Comb Mech Conc	26.3	2.55	0.86	26.7	5.91	60.0	2.49	10.2
Comb Mech Tail	65.6	0.20	0.06	0.90	0.53	1.7	0.17	3.2
Col + P.Rghr Feed	100.0	1.40	0.64	10.3	3.44	21.4	1.85	6.2
Col + P.Rghr Conc	13.9	6.53	3.89	31.2	16.7	54.2	11.3	3.2
Col + P.Rghr Tail	86.1	0.58	0.11	7.0	1.30	16.1	0.33	12.4

4.3. Metallurgical Balance - Distributions:

Product	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	34.4	90.5	94.1	94.3	90.0	94.8	94.1	12.6
Final Tail	65.6	9.5	5.9	5.7	10.0	5.2	5.9	87.4
Unit Column Feed	327.1	165.8	203.0	211.9	159.2	219.6	203.0	369.4
Unit Column Conc	8.1	42.5	58.6	26.0	44.6	21.0	58.6	1.3
Unit Column Tail	319.0	123.2	144.4	185.8	114.6	198.6	144.4	368.1
Prim Rghr Feed	91.9	57.4	41.4	74.0	55.3	79.0	41.4	98.7
Prim Rghr Conc	5.8	21.6	25.8	15.8	22.3	14.2	25.8	2.1
Prim Rghr Tail	86.1	35.8	15.6	58.2	33.0	64.8	15.6	96.6
Sec Rghr Feed	86.1	35.4	15.4	58.1	32.5	64.9	15.4	96.6
Sec Rghr Conc	0.8	2.0	1.9	1.5	2.1	1.4	1.9	0.5
Sec Rghr Tail	85.3	33.4	13.5	56.6	30.5	63.4	13.5	96.1
Comb Rghr Feed	91.9	57.4	41.4	74.0	55.3	79.0	41.4	98.7
Comb Rghr Conc	6.6	23.6	27.6	17.4	24.4	15.6	27.6	2.6
Comb Rghr Tail	85.3	33.8	13.7	56.6	30.9	63.4	13.7	96.1
Scavenger Feed	85.3	33.5	13.5	56.6	30.5	63.4	13.5	96.1
Scavenger Conc	19.7	23.9	7.7	50.9	20.4	58.4	7.7	8.7
Scavenger Tail	65.6	9.5	5.8	5.7	10.1	5.1	5.8	87.4
Comb Mech Feed	91.9	57.4	41.4	74.0	55.3	79.0	41.4	98.7
Comb Mech Conc	26.3	47.9	35.5	68.2	45.3	73.9	35.5	11.3
Comb Mech Tail	65.6	9.5	5.9	5.7	10.0	5.2	5.9	87.4
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	13.9	64.6	84.6	41.9	67.5	35.1	84.6	3.4
Col + P.Rghr Tail	86.1	35.4	15.4	58.1	32.5	64.9	15.4	96.6

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	34.4	90.5	94.1	94.3	90.0	94.8	94.1	12.6
Final Tail	65.6	9.5	5.9	5.7	10.0	5.2	5.9	87.4
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	2.5	25.7	28.9	12.3	28.0	9.6	28.9	0.4
Unit Column Tail	97.5	74.3	71.1	87.7	72.0	90.4	71.1	99.6
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	6.3	37.5	62.3	21.4	40.3	18.0	62.3	2.1
Prim Rghr Tail	93.7	62.5	37.7	78.6	59.7	82.0	37.7	97.9
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	0.9	5.7	12.2	2.6	6.4	2.2	12.2	0.5
Sec Rghr Tail	99.1	94.3	87.8	97.4	93.6	97.8	87.8	99.5
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	7.2	41.0	66.9	23.5	44.1	19.8	66.9	2.6
Comb Rghr Tail	92.8	59.0	33.1	76.5	55.9	80.2	33.1	97.4
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	23.1	71.5	56.8	90.0	66.9	92.0	56.8	9.1
Scavenger Tail	76.9	28.5	43.2	10.0	33.1	8.0	43.2	90.9
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	28.6	83.5	85.8	92.2	81.9	93.5	85.8	11.5
Comb Mech Tail	71.4	16.5	14.2	7.8	18.1	6.5	14.2	88.5
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	13.9	64.6	84.6	41.9	67.5	35.1	84.6	3.4
Col + P.Rghr Tail	86.1	35.4	15.4	58.1	32.5	64.9	15.4	96.6

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	114.3	15.3	15.3	84.7
6	3,327	104.5	14.0	29.3	70.7
8	2,362	84.2	11.3	40.6	59.4
10	1,651	73.5	9.8	50.4	49.6
14	1,168	49.0	6.6	57.0	43.0
20	833	34.8	4.7	61.7	38.3
28	589	31.9	4.3	66.0	34.0
35	417	29.2	3.9	69.9	30.1
48	295	24.4	3.3	73.1	26.9
65	208	25.3	3.4	76.5	23.5
100	147	26.1	3.5	80.0	20.0
150	104	22.7	3.0	83.1	16.9
200	74	22.5	3.0	86.1	13.9
270	53	21.7	2.9	89.0	11.0
400	37	14.8	2.0	91.0	9.0
Pan	-37	67.4	9.0	100.0	-
Total	-	**746.3**	**100.0**	-	-
K80	**4,233**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.9	0.3	0.3	99.7
14	1,168	11.9	4.0	4.3	95.7
20	833	18.2	6.1	10.4	89.6
28	589	31.9	10.7	21.1	78.9
35	417	35.2	11.8	32.9	67.1
48	295	28.5	9.5	42.4	57.6
65	208	24.4	8.2	50.6	49.4
100	147	24.1	8.1	58.7	41.3
150	104	20.6	6.9	65.6	34.4
200	74	17.9	6.0	71.6	28.4
270	53	18.0	6.0	77.6	22.4
400	37	13.2	4.4	82.0	18.0
Pan	-37	53.7	18.0	100.0	-
Total	-	**298.5**	**100.0**	-	-
K80	**619**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.0	0.5	0.5	99.5
14	1,168	31.5	7.3	7.7	92.3
20	833	47.5	10.9	18.7	81.3
28	589	77.1	17.8	36.4	63.6
35	417	89.9	20.7	57.1	42.9
48	295	85.2	19.6	76.8	23.2
65	208	62.0	14.3	91.1	8.9
100	147	19.8	4.6	95.6	4.4
150	104	6.6	1.5	97.1	2.9
200	74	2.8	0.6	97.8	2.2
270	53	1.5	0.3	98.1	1.9
400	37	1.2	0.3	98.4	1.6
Pan	-37	6.9	1.6	100.0	-
Total	-	**434.0**	**100.0**	-	-
K80	**809**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	8.4	2.9	2.9	97.1
14	1,168	16.4	5.6	8.5	91.5
20	833	24.5	8.4	16.8	83.2
28	589	34.3	11.7	28.6	71.4
35	417	41.1	14.0	42.6	57.4
48	295	42.0	14.3	57.0	43.0
65	208	38.8	13.3	70.2	29.8
100	147	24.0	8.2	78.4	21.6
150	104	14.2	4.9	83.3	16.7
200	74	9.7	3.3	86.6	13.4
270	53	8.4	2.9	89.4	10.6
400	37	6.3	2.2	91.6	8.4
Pan	-37	24.6	8.4	100.0	-
Total	-	**292.7**	**100.0**	-	-
K80	**757**				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	7.7	2.1	2.1	97.9
14	1,168	14.9	4.0	6.1	93.9
20	833	24.1	6.5	12.5	87.5
28	589	38.1	10.2	22.7	77.3
35	417	44.5	11.9	34.7	65.3
48	295	42.6	11.4	46.1	53.9
65	208	42.1	11.3	57.4	42.6
100	147	32.5	8.7	66.1	33.9
150	104	23.1	6.2	72.3	27.7
200	74	19.0	5.1	77.4	22.6
270	53	16.7	4.5	81.9	18.1
400	37	12.8	3.4	85.3	14.7
Pan	-37	54.7	14.7	100.0	-
Total	-	**372.8**	**100.0**	-	-
K80	**650**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	4.6	2.9	2.9	97.1
100	147	7.2	4.5	7.4	92.6
150	104	10.9	6.9	14.3	85.7
200	74	16.1	10.1	24.4	75.6
270	53	19.4	12.2	36.6	63.4
400	37	18.9	11.9	48.5	51.5
Pan	-37	81.9	51.5	100.0	-
Total	-	**159.0**	**100.0**	-	-
K80	**86**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.8	0.2	0.2	99.8
14	1,168	22.8	6.9	7.1	92.9
20	833	33.1	10.0	17.2	82.8
28	589	44.3	13.4	30.6	69.4
35	417	43.3	13.1	43.7	56.3
48	295	37.0	11.2	54.9	45.1
65	208	32.6	9.9	64.8	35.2
100	147	22.0	6.7	71.4	28.6
150	104	15.4	4.7	76.1	23.9
200	74	13.1	4.0	80.0	20.0
270	53	11.9	3.6	83.7	16.3
400	37	9.4	2.8	86.5	13.5
Pan	-37	44.6	13.5	100.0	-
Total	-	**330.3**	**100.0**	-	-
K80	**776**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	11.9	8.2	8.2	91.8
100	147	20.1	13.9	22.2	77.8
150	104	18.6	12.9	35.1	64.9
200	74	17.5	12.1	47.2	52.8
270	53	14.5	10.0	57.2	42.8
400	37	11.9	8.2	65.5	34.5
Pan	-37	49.8	34.5	100.0	-
Total	-	**144.3**	**100.0**	-	-
K80	**155**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	4.6	2.5	2.5	97.5
100	147	16.0	8.8	11.4	88.6
150	104	16.2	9.0	20.3	79.7
200	74	17.3	9.6	29.9	70.1
270	53	20.0	11.0	40.9	59.1
400	37	18.2	10.1	51.0	49.0
Pan	-37	88.7	49.0	100.0	-
Total	-	**181.0**	**100.0**	-	-
K80	**105**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.9	1.5	1.5	98.5
100	147	2.2	3.5	5.0	95.0
150	104	2.4	3.9	8.9	91.1
200	74	3.8	6.1	15.0	85.0
270	53	5.9	9.5	24.5	75.5
400	37	6.2	10.0	34.5	65.5
Pan	-37	40.6	65.5	100.0	-
Total	-	**62.0**	**100.0**	-	-
K80	**62**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	14.3	8.6	8.6	91.4
100	147	27.5	16.5	25.1	74.9
150	104	22.6	13.6	38.6	61.4
200	74	18.8	11.3	49.9	50.1
270	53	15.2	9.1	59.0	41.0
400	37	12.4	7.4	66.5	33.5
Pan	-37	55.9	33.5	100.0	-
Total	-	**166.7**	**100.0**	-	-
K80	**165**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data

(based on 60 mesh Kason screen with 234 µm aperture)

C L R
189%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	42.4	57.0	76.8	0.0
-48+100	16.2	21.5	18.8	22.2
-100+200	12.9	8.2	2.2	25.0
-200+400	10.5	5.0	0.6	18.3
-400	18.0	8.4	1.6	34.5

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	214 %	52.3	112 %
-48+100	227 %	19.9	45 %
-100+200	202 %	9.7	20 %
-200+400	178 %	7.0	12 %
-400	242 %	11.1	27 %
Total		100.0	189 %

1. Purpose: To duplicate the conditions of test PP-32.

2. Procedure: All process units started, including unit column.

2.1. Flowsheet: The flowsheet is shown in Figure 1b.

2.2. Equipment: The equipment list is shown in Table 1b.

3. Results:

Flotation Feed Size		70.8 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.39	0.58	3.38	1.67	6.62
Unit Column	Grade	5.21	6.71	12.9	19.5	3.93
	Recov	8.9	27.6	9.0	27.6	0.56
Primary Rougher	Grade	4.23	2.90	10.48	8.42	5.05
	Recov	28.8	47.5	29.2	47.5	3.66
Secondary Rougher	Grade	4.78	2.25	12.11	6.51	4.16
	Recov	5.0	5.6	5.2	5.6	0.62
Scavenger	Grade	2.68	0.32	6.31	0.93	9.6
	Recov	44.9	12.9	43.3	12.9	10.35
Overall Circuit	Grade	3.33	1.48	8.05	4.30	7.13
	Recov	87.6	93.8	86.8	93.8	15.19

Although an attempt was made to keep all operating conditions the same, the unit column pulled a significantly lower mass fraction, at lower grade. It was suspected that the sintered steel sparger may have been showing signs of scaling. The sparger was removed and acid cleaned for the next test.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	195.2 kg/h of -1/4 inch feed (Wet Sple 1060.1 g)
	(Dry Sple 1051.7 g)
Feed Rate:	193.6 kg/h of dry ore. (Moisture 0.79 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 765 kg in 3.92 hr
	Sample 293 kg in 1.50 hr
Rod Mill Discharge:	1,560 g/L (52 % Sol at Solid SG of 3.30)
	40.3 % plus 48 mesh
	42.5 % minus 100 mesh
Input Power:	34.52 for 3 disc revolutions
	1.13 kW (95% drive efficiency)
Average Power:	1.07 kW Gross
	0.47 kW No Load
	0.60 kW Net
Net Power Usage:	3.08 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,040 microns
K80 Product:	584 microns
Work Index (metric):	12.0

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 397 % circ. load)
Feed Rate:	767.8 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,163 g/L (20 % Sol at S 3.30)
Ball Mill Discharge:	1,590 g/L (53 % Sol at S 3.30)
	70.8 % plus 48 mesh
	9.9 % minus 100 mesh
Input Power:	27.51 for 3 disc revolutions
	1.41 kW (95% drive efficiency)
Average Power:	1.34 kW Gross
	0.52 kW No Load
	0.82 kW Net
Net Power Usage:	1.07 kWh/tonne of screen oversize.
K80 Feed:	584 microns
K80 Product:	181 microns
Work Index (metric):	3.2

3.1.3. Overall Mill Report:

Net Power Usage:	4.14 kWh/t
K80 Feed:	4,040 microns
K80 Product:	181 microns
Work Index (metric):	7.1
Screen Undersize:	70.8 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,040	19.2
Rod Mill Discharge	584	42.5
Ball Mill Feed	804	3.4
Ball Mill Discharge	767	9.9
Column Feed	746	16.5
Column Conc	90	93.0
Screen Feed	738	17.8
Screen Undersize	181	70.8
Prim Rghr Conc	181	71.7
Sec Rghr Conc	86	87.3
Scavenger Tail	163	75.6

3.2. Reagent Additions:

Average Feed Rate: 0.194 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Column Feed	NaIX	2.0%	3.0	18.6
	DF-250	2.0%	5.2	32.2
Rougher Feed	NaIX	2.0%	4.5	27.9
	DF-250	2.0%	3.1	19.2
Scavenger 1 Feed	NaIX	2.0%	7.3	45.2
	DF-250	2.0%	2.2	13.6
	CuSO4	2.0%	5.8	35.9
Scavenger 2 Feed	NaIX	2.0%	5.0	31.0
	DF-250	2.0%	4.3	26.6
Total	**NaIX**		19.8	**122.7**
	DF-250		14.8	**91.7**
	CuSO4		5.8	**35.9**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,560			3.39
Ball Mill Discharge	1,590			
Screen Feed	1,503	9.58		
Screen Undersize	1,163	9.26	25.5	
Scavenger 1 Feed	1,160	8.40		
Scavenger 2 Tail	1,245			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	961	1.55	20.7	2.0
Primary Rougher	56	189	1.26	8.5	6.6
Secondary Rougher	28	171	1.23	8.7	3.2
Scavenger	336	168	1.23	8.8	38.3
Total	420				48.1

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 484%** **From BILCO 397%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.34	0.67	10.4	1.39	0.58	10.6	193.6	100.00
Rod Mill Discharge	1.33	0.68	10.2	1.39	0.58	10.6	193.6	100.00
Ball Mill Feed	0.53	0.36	6.24	0.57	0.37	6.28	767.8	396.52
Ball Mill Discharge	0.57	0.36	6.15	0.57	0.37	6.28	767.8	396.52
Unit Column Feed	0.94	0.53	7.91	0.74	0.41	7.15	961.5	496.52
Unit Column Conc	5.36	6.21	33.6	5.21	6.71	31.4	4.6	2.37
Screen Feed	0.70	0.36	6.53	0.72	0.38	7.04	956.9	494.15
Screen Undersize	1.29	0.35	9.82	1.29	0.43	10.1	189.1	97.63
Prim Rghr Conc	4.31	2.85	28.3	4.23	2.90	27.6	18.2	9.42
Prim Rghr Tail	0.95	0.15	7.81	0.98	0.16	8.26	170.8	88.21
Sec Rghr Conc	4.78	2.27	26.1	4.78	2.25	26.4	2.8	1.45
Sec Rghr Tail	1.00	0.130	10.3	0.92	0.127	7.96	168.0	86.76
Scavenger Conc	2.66	0.330	25.5	2.68	0.321	26.5	45.0	23.23
Scavenger Tail	0.27	0.057	1.19	0.27	0.056	1.19	123.0	63.54

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.39	0.58	10.6	3.38	22.4	1.67	6.6
Combined Conc	36.5	3.33	1.48	27.1	8.05	57.4	4.30	7.1
Final Tail	63.5	0.27	0.06	1.19	0.70	2.3	0.16	3.2
Unit Column Feed	496.5	0.74	0.41	7.15	1.73	15.4	1.20	9.0
Unit Column Conc	2.4	5.21	6.71	31.38	12.87	50.6	19.46	3.9
Unit Column Tail	494.1	0.72	0.38	7.04	1.67	15.3	1.11	9.1
Prim Rghr Feed	97.6	1.29	0.43	10.12	3.15	21.7	1.24	6.9
Prim Rghr Conc	9.4	4.23	2.90	27.6	10.48	52.9	8.42	5.0
Prim Rghr Tail	88.2	0.98	0.16	8.26	2.36	18.4	0.47	7.8
Sec Rghr Feed	88.2	0.98	0.16	8.26	2.36	18.4	0.47	7.8
Sec Rghr Conc	1.4	4.78	2.25	26.4	12.11	50.4	6.51	4.2
Sec Rghr Tail	86.8	0.92	0.13	7.96	2.20	17.8	0.37	8.1
Comb Rghr Feed	97.6	1.29	0.43	10.12	3.15	21.7	1.24	6.9
Comb Rghr Conc	10.9	4.31	2.81	27.4	10.70	52.6	8.16	4.9
Comb Rghr Tail	86.8	0.92	0.13	7.96	2.20	17.8	0.37	8.1
Scavenger Feed	86.8	0.92	0.13	7.96	2.20	17.8	0.37	8.1
Scavenger Conc	23.2	2.68	0.32	26.5	6.31	60.4	0.93	9.6
Scavenger Tail	63.5	0.27	0.06	1.19	0.70	2.3	0.16	3.2
Comb Mech Feed	97.6	1.29	0.43	10.12	3.15	21.7	1.24	6.9
Comb Mech Conc	34.1	3.20	1.12	26.8	7.71	57.9	3.24	7.5
Comb Mech Tail	63.5	0.27	0.06	1.19	0.70	2.3	0.16	3.2
Col + P.Rghr Feed	100.0	1.39	0.58	10.6	3.38	22.4	1.67	6.6
Col + P.Rghr Conc	11.8	4.43	3.67	28.3	11.0	52.4	10.6	4.8
Col + P.Rghr Tail	88.2	0.98	0.16	8.3	2.36	18.4	0.47	7.8

4.3. Metallurgical Balance - Distributions:

Product	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	36.5	87.6	93.8	92.9	86.8	93.6	93.8	15.2
Final Tail	63.5	12.4	6.2	7.1	13.2	6.4	6.2	84.8
Unit Column Feed	496.5	264.2	356.9	334.2	253.6	342.8	356.9	558.5
Unit Column Conc	2.4	8.9	27.6	7.0	9.0	5.4	27.6	0.6
Unit Column Tail	494.1	255.3	329.2	327.2	244.5	337.4	329.2	557.9
Prim Rghr Feed	97.6	91.1	72.2	93.0	91.0	94.7	72.2	99.4
Prim Rghr Conc	9.4	28.8	47.5	24.4	29.2	22.3	47.5	3.7
Prim Rghr Tail	88.2	62.3	24.7	68.6	61.7	72.4	24.7	95.8
Sec Rghr Feed	88.2	62.3	24.8	68.6	61.7	72.4	24.8	95.8
Sec Rghr Conc	1.4	5.0	5.6	3.6	5.2	3.3	5.6	0.6
Sec Rghr Tail	86.8	57.3	19.2	65.0	56.5	69.1	19.2	95.2
Comb Rghr Feed	97.6	91.1	72.2	93.0	91.0	94.7	72.2	99.4
Comb Rghr Conc	10.9	33.7	53.1	28.0	34.4	25.5	53.1	4.3
Comb Rghr Tail	86.8	57.3	19.1	65.0	56.5	69.1	19.1	95.2
Scavenger Feed	86.8	57.3	19.1	65.0	56.5	69.1	19.1	95.2
Scavenger Conc	23.2	44.9	12.9	57.8	43.3	62.7	12.9	10.4
Scavenger Tail	63.5	12.4	6.2	7.1	13.2	6.4	6.2	84.8
Comb Mech Feed	97.6	91.1	72.2	93.0	91.0	94.7	72.2	99.4
Comb Mech Conc	34.1	78.7	66.0	85.9	77.8	88.2	66.0	14.6
Comb Mech Tail	63.5	12.4	6.2	7.1	13.2	6.4	6.2	84.8
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	11.8	37.7	75.2	31.4	38.3	27.6	75.2	4.2
Col + P.Rghr Tail	88.2	62.3	24.8	68.6	61.7	72.4	24.8	95.8

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	36.5	87.6	93.8	92.9	86.8	93.6	93.8	15.2
Final Tail	63.5	12.4	6.2	7.1	13.2	6.4	6.2	84.8
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	0.5	3.4	7.7	2.1	3.6	1.6	7.7	0.1
Unit Column Tail	99.5	96.6	92.3	97.9	96.4	98.4	92.3	99.9
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	9.7	31.6	65.7	26.3	32.1	23.5	65.7	3.7
Prim Rghr Tail	90.3	68.4	34.3	73.7	67.9	76.5	34.3	96.3
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	1.6	8.0	22.7	5.2	8.4	4.5	22.7	0.6
Sec Rghr Tail	98.4	92.0	77.3	94.8	91.6	95.5	77.3	99.4
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	11.1	37.1	73.5	30.1	37.8	27.0	73.5	4.3
Comb Rghr Tail	88.9	62.9	26.5	69.9	62.2	73.0	26.5	95.7
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	26.8	78.4	67.7	89.0	76.7	90.7	67.7	10.9
Scavenger Tail	73.2	21.6	32.3	11.0	23.3	9.3	32.3	89.1
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	34.9	86.4	91.4	92.3	85.5	93.2	91.4	14.7
Comb Mech Tail	65.1	13.6	8.6	7.7	14.5	6.8	8.6	85.3
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	11.8	37.7	75.2	31.4	38.3	27.6	75.2	4.2
Col + P.Rghr Tail	88.2	62.3	24.8	68.6	61.7	72.4	24.8	95.8

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	70.4	13.5	13.5	86.5
6	3,327	79.2	15.2	28.7	71.3
8	2,362	62.5	12.0	40.7	59.3
10	1,651	76.9	14.8	55.5	44.5
14	1,168	11.5	2.2	57.7	42.3
20	833	28.1	5.4	63.1	36.9
28	589	23.4	4.5	67.5	32.5
35	417	19.8	3.8	71.3	28.7
48	295	16.9	3.2	74.6	25.4
65	208	15.8	3.0	77.6	22.4
100	147	16.6	3.2	80.8	19.2
150	104	14.6	2.8	83.6	16.4
200	74	14.0	2.7	86.3	13.7
270	53	14.8	2.8	89.1	10.9
400	37	9.2	1.8	90.9	9.1
Pan	-37	47.4	9.1	100.0	-
Total	-	**521.1**	**100.0**	[illegible]	-
K80	**4,040**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.2	0.7	0.7	99.3
14	1,168	7.7	2.5	3.3	96.7
20	833	18.4	6.1	9.3	90.7
28	589	31.3	10.3	19.6	80.4
35	417	34.7	11.4	31.1	68.9
48	295	28.0	9.2	40.3	59.7
65	208	27.9	9.2	49.5	50.5
100	147	24.2	8.0	57.5	42.5
150	104	20.3	6.7	64.2	35.8
200	74	18.9	6.2	70.4	29.6
270	53	16.4	5.4	75.8	24.2
400	37	11.5	3.8	79.6	20.4
Pan	-37	61.9	20.4	100.0	-
Total	-	**303.4**	**100.0**	-	-
K80	**584**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	11.5	2.8	2.8	97.2
14	1,168	23.8	5.8	8.5	91.5
20	833	41.3	10.0	18.6	81.4
28	589	69.9	16.9	35.5	64.5
35	417	91.0	22.0	57.5	42.5
48	295	90.4	21.9	79.4	20.6
65	208	55.7	13.5	92.9	7.1
100	147	15.2	3.7	96.6	3.4
150	104	4.5	1.1	97.7	2.3
200	74	1.8	0.4	98.1	1.9
270	53	0.8	0.2	98.3	1.7
400	37	0.4	0.1	98.4	1.6
Pan	-37	6.6	1.6	100.0	-
Total	-	**412.9**	**100.0**	-	-
K80	**804**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.7	0.6	0.6	99.4
14	1,168	21.3	7.2	7.8	92.2
20	833	26.6	9.0	16.7	83.3
28	589	43.0	14.5	31.2	68.8
35	417	57.2	19.3	50.5	49.5
48	295	60.0	20.2	70.8	29.2
65	208	41.5	14.0	84.8	15.2
100	147	15.7	5.3	90.1	9.9
150	104	7.3	2.5	92.5	7.5
200	74	4.4	1.5	94.0	6.0
270	53	3.0	1.0	95.0	5.0
400	37	1.9	0.6	95.7	4.3
Pan	-37	12.8	4.3	100.0	-
Total	-	**296.4**	**100.0**	-	-
K80	**767**				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.1	0.3	0.3	99.7
14	1,168	22.0	6.6	6.9	93.1
20	833	28.7	8.6	15.6	84.4
28	589	47.3	14.2	29.8	70.2
35	417	59.6	17.9	47.7	52.3
48	295	59.0	17.7	65.5	34.5
65	208	39.6	11.9	77.4	22.6
100	147	20.3	6.1	83.5	16.5
150	104	11.3	3.4	86.9	13.1
200	74	8.1	2.4	89.3	10.7
270	53	7.0	2.1	91.4	8.6
400	37	5.1	1.5	92.9	7.1
Pan	-37	23.5	7.1	100.0	-
Total	**-**	**332.6**	**100.0**	**-**	**-**
K80	**746**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.5	2.7	2.7	97.3
100	147	4.0	4.3	7.0	93.0
150	104	7.4	7.9	14.9	85.1
200	74	10.6	11.4	26.3	73.7
270	53	13.4	14.4	40.7	59.3
400	37	12.7	13.6	54.3	45.7
Pan	-37	42.6	45.7	100.0	-
Total	**-**	**93.2**	**100.0**	**-**	**-**
K80	**90**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.9	2.3	2.3	97.7
14	1,168	13.5	4.5	6.8	93.2
20	833	24.8	8.3	15.2	84.8
28	589	41.6	14.0	29.1	70.9
35	417	52.0	17.5	46.6	53.4
48	295	49.8	16.7	63.3	36.7
65	208	37.9	12.7	76.0	24.0
100	147	18.5	6.2	82.2	17.8
150	104	11.1	3.7	86.0	14.0
200	74	8.1	2.7	88.7	11.3
270	53	5.7	1.9	90.6	9.4
400	37	4.0	1.3	91.9	8.1
Pan	-37	24.0	8.1	100.0	-
Total	-	**297.9**	**100.0**	-	-
K80	**738**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	21.6	13.0	13.0	87.0
100	147	26.7	16.1	29.2	70.8
150	104	20.9	12.6	41.8	58.2
200	74	17.6	10.6	52.4	47.6
270	53	14.0	8.5	60.9	39.1
400	37	10.5	6.3	67.2	32.8
Pan	-37	54.3	32.8	100.0	-
Total	-	**165.6**	**100.0**	-	-
K80	**181**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	13.9	10.3	10.3	89.7
100	147	24.2	18.0	28.3	71.7
150	104	15.3	11.4	39.7	60.3
200	74	9.5	7.1	46.8	53.2
270	53	8.0	5.9	52.7	47.3
400	37	6.8	5.1	57.8	42.2
Pan	-37	56.8	42.2	100.0	-
Total	-	**134.5**	**100.0**	-	-
K80	**181**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.5	6.6	6.6	93.4
100	147	2.3	6.1	12.7	87.3
150	104	1.5	4.0	16.6	83.4
200	74	2.1	5.5	22.2	77.8
270	53	3.0	7.9	30.1	69.9
400	37	2.6	6.9	36.9	63.1
Pan	-37	23.9	63.1	100.0	-
Total	-	**37.9**	**100.0**	-	-
K80	**86**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	12.4	8.2	8.2	91.8
100	147	24.6	16.2	24.4	75.6
150	104	20.2	13.3	37.7	62.3
200	74	16.4	10.8	48.5	51.5
270	53	15.0	9.9	58.4	41.6
400	37	10.5	6.9	65.3	34.7
Pan	-37	52.6	34.7	100.0	-
Total	-	**151.7**	**100.0**	-	-
K80	**163**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 µm aperture)

C L R
449%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	40.3	70.8	79.4	0.0
-48+100	17.2	19.3	17.2	29.2
-100+200	12.9	3.9	1.5	23.2
-200+400	9.2	1.7	0.3	14.8
-400	20.4	4.3	1.6	32.8

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	467 %	65.4	305 %
-48+100	564 %	19.0	107 %
-100+200	427 %	5.7	24 %
-200+400	411 %	3.1	13 %
-400	455 %	6.8	31 %
Total		100.0	**449 %**

1. **Purpose:** To conduct a comparison test without the unit column.

2. **Procedure:** All process units started with the exception of the unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		75.1 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.25	0.59	3.06	1.71	6.18
Unit Column	Grade	--	--	--	--	--
	Recov	--	--	--	--	--
Primary Rougher	Grade	6.87	4.42	17.75	12.82	2.59
	Recov	61.3	83.4	64.6	83.4	3.41
Secondary Rougher	Grade	3.96	1.65	10.00	4.79	4.35
	Recov	1.0	0.9	1.0	0.9	0.17
Scavenger	Grade	1.54	0.25	3.21	0.71	17.8
	Recov	27.3	9.2	23.3	9.2	11.34
Overall Circuit	Grade	3.33	1.65	8.10	4.77	6.58
	Recov	89.7	93.7	89.0	93.7	14.89

The unit column was removed from the circuit by the simple expedient of reducing the gas rate to nearly zero. A slight flow was mainteined in order to prevent blockage of the sparger, but no concentrate was produced.
All reagents plus column wash water were left as in the previous test, so that all circuit reagents and dilutions would be essentially unchanged.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	199.1 kg/h of -1/4 inch feed (Wet Sple 1970.7 g)
	(Dry Sple 1946.1 g)
Feed Rate:	196.6 kg/h of dry ore. (Moisture 1.25 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 996 kg in 5.00 hr
	Sample 398 kg in 2.00 hr
Rod Mill Discharge:	1,638 g/L (55 % Sol at Solid SG of 3.39)
	37.3 % plus 48 mesh
	44.1 % minus 100 mesh
Input Power:	34.71 for 3 disc revolutions
	1.12 kW (95% drive efficiency)
Average Power:	1.06 kW Gross
	0.47 kW No Load
	0.59 kW Net
Net Power Usage:	3.00 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,420 microns
K80 Product:	537 microns
Work Index (metric):	10.7

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 242 % circ. load)
Feed Rate:	476.5 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,170 g/L (21 % Sol at S 3.39)
Ball Mill Discharge:	1,815 g/L (64 % Sol at S 3.39)
	63.4 % plus 48 mesh
	15.2 % minus 100 mesh
Input Power:	28.74 for 3 disc revolutions
	1.35 kW (95% drive efficiency)
Average Power:	1.29 kW Gross
	0.52 kW No Load
	0.76 kW Net
Net Power Usage:	1.60 kWh/tonne of screen oversize.
K80 Feed:	537 microns
K80 Product:	166 microns
Work Index (metric):	4.6

3.1.3. Overall Mill Report:

Net Power Usage:	4.60 kWh/t
K80 Feed:	4,420 microns
K80 Product:	166 microns
Work Index (metric):	7.4
Screen Undersize:	75.1 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,420	19.3
Rod Mill Discharge	537	44.1
Ball Mill Feed	804	4.6
Ball Mill Discharge	674	15.2
Screen Feed	611	30.1
Screen Undersize	166	75.1
Prim Rghr Conc	113	87.4
Sec Rghr Conc	60	93.3
Scavenger Tail	164	75.2

3.2. Reagent Additions:

Average Feed Rate: 0.197 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	NaIX	2.0%	7.7	47.0
	DF-250	2.0%	7.5	45.8
Scavenger 1 Feed	NaIX	2.0%	7.1	43.3
	DF-250	2.0%	1.9	11.6
	CuSO4	2.0%	6.2	37.8
Scavenger 2 Feed	NaIX	2.0%	5.1	31.1
	DF-250	2.0%	3.9	23.8
Total	**NaIX**		19.9	**121.4**
	DF-250		13.3	**81.2**
	CuSO4		6.2	**37.8**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,638			3.39
Ball Mill Discharge	1,815			
Screen Feed	1,399	9.68		
Screen Undersize	1,170	9.28	25.9	
Scavenger 1 Feed	1,176	8.58		
Scavenger 2 Tail	1,220			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	--	--	--	--
Primary Rougher	56	197	1.17	13.6	4.1
Secondary Rougher	28	175	1.18	11.4	2.5
Scavenger	336	174	1.20	10.2	32.8
Total	420				39.4

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 187%** **From BILCO 242%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.21	0.58	8.53	1.25	0.59	9.15	196.6	100.00
Rod Mill Discharge	1.20	0.59	9.0	1.25	0.59	9.15	196.6	100.00
Ball Mill Feed	0.39	0.30	4.56	0.39	0.35	4.57	476.5	242.34
Ball Mill Discharge	0.41	0.30	4.78	0.39	0.35	4.57	476.5	242.34
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Screen Feed	0.61	0.41	5.70	0.64	0.42	5.91	673.2	342.34
Screen Undersize	1.44	0.63	10.7	1.25	0.59	9.15	196.6	100.00
Prim Rghr Conc	6.97	4.35	29.3	6.87	4.42	28.8	21.9	11.13
Prim Rghr Tail	0.56	0.10	6.89	0.54	0.11	6.68	174.7	88.87
Sec Rghr Conc	3.95	1.66	22.2	3.96	1.65	22.4	0.6	0.32
Sec Rghr Tail	0.56	0.100	7.55	0.53	0.103	6.62	174.1	88.55
Scavenger Conc	1.46	0.270	22.1	1.54	0.246	24.00	43.5	22.15
Scavenger Tail	0.19	0.059	0.81	0.19	0.056	0.82	130.6	66.41

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall	Metal Assays			Mineral Assays			Ratio
	Wt %	% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.25	0.59	9.1	3.06	18.9	1.71	6.2
Combined Conc	33.6	3.33	1.65	25.6	8.10	53.3	4.77	6.6
Final Tail	66.4	0.19	0.06	0.82	0.50	1.5	0.16	2.9
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	1.25	0.59	9.15	3.06	18.9	1.71	6.2
Prim Rghr Conc	11.1	6.87	4.42	28.8	17.75	46.0	12.82	2.6
Prim Rghr Tail	88.9	0.54	0.11	6.68	1.21	15.5	0.32	12.8
Sec Rghr Feed	88.9	0.54	0.11	6.68	1.21	15.5	0.32	12.8
Sec Rghr Conc	0.3	3.96	1.65	22.4	10.00	43.5	4.79	4.3
Sec Rghr Tail	88.6	0.53	0.10	6.62	1.18	15.4	0.30	13.1
Comb Rghr Feed	100.0	1.25	0.59	9.15	3.06	18.9	1.71	6.2
Comb Rghr Conc	11.4	6.79	4.34	28.6	17.53	45.9	12.60	2.6
Comb Rghr Tail	88.6	0.53	0.10	6.62	1.18	15.4	0.30	13.1
Scavenger Feed	88.6	0.53	0.10	6.62	1.18	15.4	0.30	13.1
Scavenger Conc	22.1	1.54	0.25	24.0	3.21	57.0	0.71	17.8
Scavenger Tail	66.4	0.19	0.06	0.82	0.50	1.5	0.16	2.9
Comb Mech Feed	100.0	1.25	0.59	9.15	3.06	18.9	1.71	6.2
Comb Mech Conc	33.6	3.33	1.65	25.6	8.10	53.3	4.77	6.6
Comb Mech Tail	66.4	0.19	0.06	0.82	0.50	1.5	0.16	2.9
Col + P.Rghr Feed	100.0	1.25	0.59	9.1	3.06	18.9	1.71	6.2
Col + P.Rghr Conc	11.1	6.89	4.43	28.9	17.8	46.1	12.9	2.6
Col + P.Rghr Tail	88.9	0.54	0.11	6.7	1.21	15.5	0.32	12.8

4.3. Metallurgical Balance - Distributions:

Product	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	33.6	89.7	93.7	94.1	89.0	94.8	93.7	14.9
Final Tail	66.4	10.3	6.3	5.9	11.0	5.2	6.3	85.1
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	11.1	61.3	83.4	35.0	64.6	27.1	83.4	3.4
Prim Rghr Tail	88.9	38.7	16.6	65.0	35.4	72.9	16.6	96.6
Sec Rghr Feed	88.9	38.5	16.4	64.9	35.2	72.9	16.4	96.6
Sec Rghr Conc	0.3	1.0	0.9	0.8	1.0	0.7	0.9	0.2
Sec Rghr Tail	88.6	37.5	15.5	64.1	34.1	72.1	15.5	96.4
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	11.4	62.3	84.3	35.8	65.7	27.8	84.3	3.6
Comb Rghr Tail	88.6	37.7	15.7	64.2	34.3	72.2	15.7	96.4
Scavenger Feed	88.6	37.5	15.5	64.1	34.1	72.1	15.5	96.4
Scavenger Conc	22.1	27.3	9.2	58.1	23.3	66.8	9.2	11.3
Scavenger Tail	66.4	10.3	6.2	6.0	10.9	5.3	6.2	85.1
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	33.6	89.7	93.7	94.1	89.0	94.8	93.7	14.9
Comb Mech Tail	66.4	10.3	6.3	5.9	11.0	5.2	6.3	85.1
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	11.1	61.5	83.6	35.1	64.8	27.1	83.6	3.4
Col + P.Rghr Tail	88.9	38.5	16.4	64.9	35.2	72.9	16.4	96.6

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	33.6	89.7	93.7	94.1	89.0	94.8	93.7	14.9
Final Tail	66.4	10.3	6.3	5.9	11.0	5.2	6.3	85.1
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	11.1	61.3	83.4	35.0	64.6	27.1	83.4	3.4
Prim Rghr Tail	88.9	38.7	16.6	65.0	35.4	72.9	16.6	96.6
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	0.4	2.6	5.5	1.2	3.0	1.0	5.5	0.2
Sec Rghr Tail	99.6	97.4	94.5	98.8	97.0	99.0	94.5	99.8
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	11.4	62.3	84.3	35.8	65.7	27.8	84.3	3.6
Comb Rghr Tail	88.6	37.7	15.7	64.2	34.3	72.2	15.7	96.4
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	25.0	72.6	59.7	90.7	68.1	92.6	59.7	11.8
Scavenger Tail	75.0	27.4	40.3	9.3	31.9	7.4	40.3	88.2
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	33.6	89.7	93.7	94.1	89.0	94.8	93.7	14.9
Comb Mech Tail	66.4	10.3	6.3	5.9	11.0	5.2	6.3	85.1
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	11.1	61.5	83.6	35.1	64.8	27.1	83.6	3.4
Col + P.Rghr Tail	88.9	38.5	16.4	64.9	35.2	72.9	16.4	96.6

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	94.4	16.9	16.9	83.1
6	3,327	81.7	14.6	31.5	68.5
8	2,362	54.4	9.7	41.3	58.7
10	1,651	53.5	9.6	50.9	49.1
14	1,168	35.8	6.4	57.3	42.7
20	833	26.2	4.7	62.0	38.0
28	589	24.6	4.4	66.4	33.6
35	417	22.5	4.0	70.4	29.6
48	295	18.9	3.4	73.8	26.2
65	208	18.9	3.4	77.2	22.8
100	147	19.8	3.5	80.7	19.3
150	104	16.8	3.0	83.8	16.2
200	74	15.6	2.8	86.5	13.5
270	53	14.6	2.6	89.2	10.8
400	37	11.5	2.1	91.2	8.8
Pan	-37	49.0	8.8	100.0	-
Total	-	**558.2**	**100.0**	-	-
K80	**4,420**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.2	0.1	0.1	99.9
14	1,168	8.0	3.2	3.3	96.7
20	833	13.6	5.5	8.8	91.2
28	589	21.0	8.4	17.2	82.8
35	417	25.5	10.3	27.5	72.5
48	295	24.4	9.8	37.3	62.7
65	208	23.9	9.6	46.9	53.1
100	147	22.3	9.0	55.9	44.1
150	104	17.6	7.1	62.9	37.1
200	74	15.8	6.4	69.3	30.7
270	53	14.0	5.6	74.9	25.1
400	37	10.8	4.3	79.3	20.7
Pan	-37	51.6	20.7	100.0	-
Total	-	**248.7**	**100.0**	-	-
K80	**537**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.8	0.3	0.3	99.7
14	1,168	19.9	7.9	8.2	91.8
20	833	26.3	10.4	18.6	81.4
28	589	41.1	16.3	34.9	65.1
35	417	54.1	21.4	56.3	43.7
48	295	58.2	23.1	79.4	20.6
65	208	32.0	12.7	92.1	7.9
100	147	8.5	3.4	95.4	4.6
150	104	3.0	1.2	96.6	3.4
200	74	1.3	0.5	97.1	2.9
270	53	0.6	0.2	97.4	2.6
400	37	0.4	0.2	97.5	2.5
Pan	-37	6.2	2.5	100.0	-
Total	-	**252.4**	**100.0**	-	-
K80	**804**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.5	0.2	0.2	99.8
14	1,168	11.1	5.2	5.5	94.5
20	833	14.7	6.9	12.4	87.6
28	589	25.6	12.1	24.5	75.5
35	417	38.0	17.9	42.4	57.6
48	295	44.4	21.0	63.4	36.6
65	208	30.9	14.6	78.0	22.0
100	147	14.4	6.8	84.8	15.2
150	104	7.6	3.6	88.4	11.6
200	74	4.9	2.3	90.7	9.3
270	53	3.5	1.7	92.4	7.6
400	37	2.7	1.3	93.6	6.4
Pan	-37	13.5	6.4	100.0	-
Total	-	**211.8**	**100.0**	-	-
K80	**674**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.2	1.4	1.4	98.6
14	1,168	7.4	3.2	4.6	95.4
20	833	13.5	5.9	10.4	89.6
28	589	23.3	10.1	20.5	79.5
35	417	33.2	14.4	34.9	65.1
48	295	36.0	15.6	50.5	49.5
65	208	27.9	12.1	62.6	37.4
100	147	16.7	7.2	69.9	30.1
150	104	10.5	4.6	74.4	25.6
200	74	8.7	3.8	78.2	21.8
270	53	8.1	3.5	81.7	18.3
400	37	6.9	3.0	84.7	15.3
Pan	-37	35.3	15.3	100.0	-
Total	-	**230.7**	**100.0**	-	-
K80	**611**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	16.4	9.8	9.8	90.2
100	147	25.1	15.1	24.9	75.1
150	104	21.0	12.6	37.5	62.5
200	74	17.9	10.8	48.3	51.7
270	53	17.1	10.3	58.6	41.4
400	37	12.9	7.7	66.3	33.7
Pan	-37	56.1	33.7	100.0	-
Total	-	**166.5**	**100.0**	-	-
K80	**166**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	5.6	3.5	3.5	96.5
100	147	14.4	9.1	12.6	87.4
150	104	15.6	9.8	22.4	77.6
200	74	16.5	10.4	32.7	67.3
270	53	17.3	10.9	43.6	56.4
400	37	16.5	10.4	54.0	46.0
Pan	-37	73.2	46.0	100.0	-
Total	-	**159.1**	**100.0**	-	-
K80	**113**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.5	3.7	3.7	96.3
100	147	2.8	3.0	6.7	93.3
150	104	2.6	2.8	9.5	90.5
200	74	4.8	5.1	14.6	85.4
270	53	7.7	8.2	22.8	77.2
400	37	7.7	8.2	31.0	69.0
Pan	-37	64.8	69.0	100.0	-
Total	-	**93.9**	**100.0**	-	-
K80	**60**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	15.3	8.4	8.4	91.6
100	147	29.9	16.4	24.8	75.2
150	104	24.7	13.5	38.3	61.7
200	74	20.3	11.1	49.5	50.5
270	53	17.3	9.5	58.9	41.1
400	37	13.4	7.3	66.3	33.7
Pan	-37	61.5	33.7	100.0	-
Total	-	**182.4**	**100.0**	-	-
K80	**164**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 µm aperture)

C L R
187%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	37.3	63.4	79.4	0.0
-48+100	18.6	21.4	16.0	24.9
-100+200	13.4	5.9	1.7	23.4
-200+400	10.0	2.9	0.4	18.0
-400	20.7	6.4	2.5	33.7

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	233 %	55.6	130 %
-48+100	119 %	20.1	24 %
-100+200	237 %	8.1	19 %
-200+400	318 %	4.6	15 %
-400	330 %	11.6	38 %
Total		100.0	**187 %**

1. Purpose: To duplicate the conditions of test PP-32, but with the unit column reintroduced into the circuit.

2. Procedure: All process units started, including unit column.

2.1. Flowsheet: The flowsheet is shown in Figure 1b.

2.2. Equipment: The equipment list is shown in Table 1b.

3. Results:

Flotation Feed Size		68.4 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.24	0.60	3.02	1.75	6.38
Unit Column	Grade	6.96	4.96	18.0	14.4	2.42
	Recov	42.6	62.2	45.1	62.2	2.40
Primary Rougher	Grade	5.07	2.20	12.90	6.38	3.93
	Recov	27.6	24.5	28.7	24.5	2.65
Secondary Rougher	Grade	3.35	1.27	8.19	3.69	6.48
	Recov	1.3	1.0	1.3	1.0	0.22
Scavenger	Grade	1.46	0.21	2.83	0.60	23.4
	Recov	20.3	6.0	16.2	6.0	6.90
Overall Circuit	Grade	3.54	1.77	8.59	5.13	6.68
	Recov	91.6	93.8	91.2	93.8	12.17

Unit column results were very similar to test PP-32.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	202.9 kg/h of -1/4 inch feed (Wet Sple 833.9 g)
	(Dry Sple 825.6 g)
Feed Rate:	200.8 kg/h of dry ore. (Moisture 1.00 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 507 kg in 2.50 hr
	Sample 304 kg in 1.50 hr
Rod Mill Discharge:	1,680 g/L (57 % Sol at Solid SG of 3.39)
	42.1 % plus 48 mesh
	42.3 % minus 100 mesh
Input Power:	33.05 for 3 disc revolutions
	1.18 kW (95% drive efficiency)
Average Power:	1.12 kW Gross
	0.47 kW No Load
	0.64 kW Net
Net Power Usage:	3.20 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,700 microns
K80 Product:	642 microns
Work Index (metric):	12.9

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 511 % circ. load)
Feed Rate:	1025.4 kg/h
Mill Speed:	40 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,150 g/L (19 % Sol at S'3.39)
Ball Mill Discharge:	1,940 g/L (69 % Sol at S'3.39)
	82.5 % plus 48 mesh
	5.6 % minus 100 mesh
Input Power:	25.27 for 3 disc revolutions
	1.54 kW (95% drive efficiency)
Average Power:	1.46 kW Gross
	0.52 kW No Load
	0.94 kW Net
Net Power Usage:	0.92 kWh/tonne of screen oversize.
K80 Feed:	642 microns
K80 Product:	192 microns
Work Index (metric):	2.8

3.1.3. Overall Mill Report:

Net Power Usage:	4.12 kWh/t
K80 Feed:	4,700 microns
K80 Product:	192 microns
Work Index (metric):	7.2
Screen Undersize:	68.4 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	4,700	16.3
Rod Mill Discharge	642	42.3
Ball Mill Feed	992	3.5
Ball Mill Discharge	972	5.6
Column Feed	896	12.3
Column Conc	105	88.2
Screen Feed	922	14.6
Screen Undersize	192	68.4
Prim Rghr Conc	166	75.6
Sec Rghr Conc	NSS	NSS
Scavenger Tail	157	77.4

3.2. Reagent Additions:

Average Feed Rate: 0.201 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Column Feed	NaIX	2.0%	2.9	17.3
	DF-250	2.0%	4.6	27.5
Rougher Feed	NaIX	2.0%	4.7	28.1
	DF-250	2.0%	2.9	17.3
Scavenger 1 Feed	NaIX	2.0%	6.7	40.0
	DF-250	2.0%	1.8	10.8
	CuSO4	2.0%	6.0	35.8
Scavenger 2 Feed	NaIX	2.0%	5.1	30.5
	DF-250	2.0%	4.1	24.5
Total	**NaIX**		19.4	**115.9**
	DF-250		13.4	**80.1**
	CuSO4		6.0	**35.8**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,680			3.39
Ball Mill Discharge	1,940			
Screen Feed	1,557	9.20		
Screen Undersize	1,150	9.00	27.0	
Scavenger 1 Feed	1,123	8.70		
Scavenger 2 Tail	1,197			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	1226.242	1.56	25.9	1.6
Primary Rougher	56	187	1.15	14.7	3.8
Secondary Rougher	28	171	1.12	16.7	1.7
Scavenger	336	170	1.15	13.3	25.2
Total	420				30.7

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 1123%** **From BILCO 446%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.16	0.62	8.89	1.24	0.60	9.29	200.8	100.00
Rod Mill Discharge	1.22	0.63	9.1	1.24	0.60	9.29	200.8	100.00
Ball Mill Feed	0.40	0.31	4.87	0.39	0.31	5.47	894.9	445.56
Ball Mill Discharge	0.37	0.33	4.73	0.39	0.31	5.47	894.9	445.56
Unit Column Feed	0.53	0.41	5.50	0.55	0.37	6.18	1,095.7	545.56
Unit Column Conc	7.54	4.64	33.10	6.96	4.96	28.4	15.2	7.57
Screen Feed	0.48	0.27	6.02	0.46	0.30	5.86	1,080.5	538.00
Screen Undersize	0.83	0.24	8.4	0.77	0.25	7.72	185.6	92.43
Prim Rghr Conc	5.10	2.19	25.8	5.07	2.20	26.8	13.5	6.72
Prim Rghr Tail	0.42	0.08	6.48	0.43	0.09	6.22	172.2	85.72
Sec Rghr Conc	3.34	1.28	22.8	3.35	1.27	25.2	0.9	0.47
Sec Rghr Tail	0.46	0.085	7.12	0.42	0.086	6.12	171.2	85.25
Scavenger Conc	1.40	0.220	23.5	1.46	0.208	27.49	34.6	17.25
Scavenger Tail	0.15	0.058	0.69	0.15	0.055	0.70	136.6	68.00

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite % Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite % Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite % Cp = (2.90 x %Cu)
Gangue % Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.24	0.60	9.3	3.02	19.2	1.75	6.4
Combined Conc	32.0	3.54	1.77	27.5	8.59	57.4	5.13	6.7
Final Tail	68.0	0.15	0.06	0.70	0.39	1.3	0.16	3.3
Unit Column Feed	545.6	0.55	0.37	6.18	1.23	13.5	1.07	11.0
Unit Column Conc	7.6	6.96	4.96	28.44	17.97	43.5	14.37	2.4
Unit Column Tail	538.0	0.46	0.30	5.86	1.00	13.1	0.87	13.2
Prim Rghr Feed	92.4	0.77	0.25	7.72	1.79	17.3	0.71	9.6
Prim Rghr Conc	6.7	5.07	2.20	26.8	12.90	50.8	6.38	3.9
Prim Rghr Tail	85.7	0.43	0.09	6.22	0.93	14.6	0.27	15.8
Sec Rghr Feed	85.7	0.43	0.09	6.22	0.93	14.6	0.27	15.8
Sec Rghr Conc	0.5	3.35	1.27	25.2	8.19	53.1	3.69	6.5
Sec Rghr Tail	85.2	0.42	0.09	6.12	0.89	14.4	0.25	16.3
Comb Rghr Feed	92.4	0.77	0.25	7.72	1.79	17.3	0.71	9.6
Comb Rghr Conc	7.2	4.96	2.14	26.7	12.59	50.9	6.20	4.0
Comb Rghr Tail	85.2	0.42	0.09	6.12	0.89	14.4	0.25	16.3
Scavenger Feed	85.2	0.42	0.09	6.12	0.89	14.4	0.25	16.3
Scavenger Conc	17.3	1.46	0.21	27.5	2.83	66.2	0.60	23.4
Scavenger Tail	68.0	0.15	0.06	0.70	0.39	1.3	0.16	3.3
Comb Mech Feed	92.4	0.77	0.25	7.72	1.79	17.3	0.71	9.6
Comb Mech Conc	24.4	2.49	0.77	27.2	5.70	61.7	2.24	10.8
Comb Mech Tail	68.0	0.15	0.06	0.70	0.39	1.3	0.16	3.3
Col + P.Rghr Feed	100.0	1.24	0.60	9.3	3.02	19.2	1.75	6.4
Col + P.Rghr Conc	14.3	6.06	3.67	27.7	15.6	46.9	10.6	3.0
Col + P.Rghr Tail	85.7	0.43	0.09	6.2	0.93	14.6	0.27	15.8

4.3. Metallurgical Balance - Distributions:

	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
Product	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	32.0	91.6	93.8	94.9	91.2	95.4	93.8	12.2
Final Tail	68.0	8.4	6.2	5.1	8.8	4.6	6.2	87.8
Unit Column Feed	545.6	240.6	333.9	363.0	222.8	383.7	333.9	604.2
Unit Column Conc	7.6	42.6	62.2	23.2	45.1	17.1	62.2	2.4
Unit Column Tail	538.0	198.0	271.7	339.8	177.7	366.6	271.7	601.8
Prim Rghr Feed	92.4	57.5	37.6	76.8	55.0	82.9	37.6	97.6
Prim Rghr Conc	6.7	27.6	24.5	19.4	28.7	17.7	24.5	2.6
Prim Rghr Tail	85.7	29.9	13.0	57.5	26.3	65.2	13.0	94.9
Sec Rghr Feed	85.7	30.0	13.1	57.5	26.3	65.2	13.1	94.9
Sec Rghr Conc	0.5	1.3	1.0	1.3	1.3	1.3	1.0	0.2
Sec Rghr Tail	85.2	28.7	12.1	56.2	25.0	63.9	12.1	94.7
Comb Rghr Feed	92.4	57.5	37.6	76.8	55.0	82.9	37.6	97.6
Comb Rghr Conc	7.2	28.8	25.5	20.6	30.0	19.0	25.5	2.9
Comb Rghr Tail	85.2	28.7	12.1	56.2	25.0	63.9	12.1	94.7
Scavenger Feed	85.2	28.7	12.2	56.2	25.0	63.9	12.2	94.7
Scavenger Conc	17.3	20.3	6.0	51.1	16.2	59.3	6.0	6.9
Scavenger Tail	68.0	8.4	6.2	5.1	8.9	4.6	6.2	87.8
Comb Mech Feed	92.4	57.5	37.6	76.8	55.0	82.9	37.6	97.6
Comb Mech Conc	24.4	49.1	31.4	71.7	46.2	78.3	31.4	9.8
Comb Mech Tail	68.0	8.4	6.2	5.1	8.8	4.6	6.2	87.8
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.3	70.0	86.9	42.5	73.7	34.8	86.9	5.1
Col + P.Rghr Tail	85.7	30.0	13.1	57.5	26.3	65.2	13.1	94.9

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	32.0	91.6	93.8	94.9	91.2	95.4	93.8	12.2
Final Tail	68.0	8.4	6.2	5.1	8.8	4.6	6.2	87.8
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	1.4	17.7	18.6	6.4	20.2	4.5	18.6	0.4
Unit Column Tail	98.6	82.3	81.4	93.6	79.8	95.5	81.4	99.6
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	7.3	47.9	65.3	25.2	52.2	21.4	65.3	2.7
Prim Rghr Tail	92.7	52.1	34.7	74.8	47.8	78.6	34.7	97.3
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	0.5	4.2	7.6	2.2	4.8	2.0	7.6	0.2
Sec Rghr Tail	99.5	95.8	92.4	97.8	95.2	98.0	92.4	99.8
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	7.8	50.2	67.9	26.9	54.5	22.9	67.9	2.9
Comb Rghr Tail	92.2	49.8	32.1	73.1	45.5	77.1	32.1	97.1
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	20.2	70.8	48.9	90.9	64.6	92.9	48.9	7.3
Scavenger Tail	79.8	29.2	51.1	9.1	35.4	7.1	51.1	92.7
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	26.4	85.5	83.5	93.3	83.9	94.5	83.5	10.0
Comb Mech Tail	73.6	14.5	16.5	6.7	16.1	5.5	16.5	90.0
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.3	70.0	86.9	42.5	73.7	34.8	86.9	5.1
Col + P.Rghr Tail	85.7	30.0	13.1	57.5	26.3	65.2	13.1	94.9

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	128.9	20.6	20.6	79.4
6	3,327	108.0	17.3	37.8	62.2
8	2,362	72.0	11.5	49.4	50.6
10	1,651	55.6	8.9	58.2	41.8
14	1,168	36.4	5.8	64.1	35.9
20	833	25.4	4.1	68.1	31.9
28	589	23.1	3.7	71.8	28.2
35	417	20.8	3.3	75.1	24.9
48	295	17.4	2.8	77.9	22.1
65	208	18.0	2.9	80.8	19.2
100	147	18.2	2.9	83.7	16.3
150	104	15.6	2.5	86.2	13.8
200	74	14.3	2.3	88.5	11.5
270	53	14.1	2.3	90.7	9.3
400	37	10.6	1.7	92.4	7.6
Pan	-37	47.5	7.6	100.0	-
Total	-	**625.9**	**100.0**	-	-
K80	**~4700**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.5	0.1	0.1	99.9
14	1,168	15.3	4.5	4.6	95.4
20	833	25.0	7.3	12.0	88.0
28	589	34.9	10.2	22.2	77.8
35	417	36.9	10.8	33.1	66.9
48	295	30.8	9.0	42.1	57.9
65	208	26.5	7.8	49.9	50.1
100	147	26.7	7.8	57.7	42.3
150	104	22.4	6.6	64.3	35.7
200	74	20.3	6.0	70.3	29.7
270	53	18.9	5.6	75.8	24.2
400	37	15.9	4.7	80.5	19.5
Pan	-37	66.4	19.5	100.0	-
Total	-	**340.5**	**100.0**	-	-
K80	**642**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.0	0.8	0.8	99.2
14	1,168	33.7	13.1	13.9	86.1
20	833	32.8	12.8	26.7	73.3
28	589	46.8	18.2	44.9	55.1
35	417	54.5	21.2	66.1	33.9
48	295	51.3	20.0	86.0	14.0
65	208	21.4	8.3	94.4	5.6
100	147	5.6	2.2	96.5	3.5
150	104	2.0	0.8	97.3	2.7
200	74	0.9	0.4	97.7	2.3
270	53	0.5	0.2	97.9	2.1
400	37	0.2	0.1	97.9	2.1
Pan	-37	5.3	2.1	100.0	-
Total	-	**257.0**	**100.0**	-	-
K80	**992**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	15.0	5.2	5.2	94.8
14	1,168	23.8	8.2	13.3	86.7
20	833	35.3	12.1	25.5	74.5
28	589	52.8	18.2	43.6	56.4
35	417	60.4	20.8	64.4	35.6
48	295	52.6	18.1	82.5	17.5
65	208	26.4	9.1	91.5	8.5
100	147	8.3	2.9	94.4	5.6
150	104	3.4	1.2	95.6	4.4
200	74	1.9	0.7	96.2	3.8
270	53	1.3	0.4	96.7	3.3
400	37	1.0	0.3	97.0	3.0
Pan	-37	8.7	3.0	100.0	-
Total	-	**290.9**	**100.0**	-	-
K80	**972**				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	13.5	3.8	3.8	96.2
14	1,168	25.7	7.2	11.0	89.0
20	833	39.0	11.0	22.0	78.0
28	589	57.6	16.2	38.2	61.8
35	417	66.6	18.7	56.9	43.1
48	295	60.4	17.0	73.9	26.1
65	208	34.7	9.8	83.7	16.3
100	147	14.2	4.0	87.7	12.3
150	104	8.2	2.3	90.0	10.0
200	74	6.3	1.8	91.8	8.2
270	53	5.2	1.5	93.2	6.8
400	37	4.0	1.1	94.3	5.7
Pan	-37	20.1	5.7	100.0	-
Total	-	**355.5**	**100.0**	-	-
K80	**896**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	6.2	6.1	6.1	93.9
100	147	5.8	5.7	11.8	88.2
150	104	8.4	8.3	20.0	80.0
200	74	10.6	10.4	30.4	69.6
270	53	12.9	12.7	43.1	56.9
400	37	11.5	11.3	54.4	45.6
Pan	-37	46.5	45.6	100.0	-
Total	-	**101.9**	**100.0**	-	-
K80	**105**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.9	0.9	0.9	99.1
14	1,168	36.1	11.3	12.3	87.7
20	833	34.5	10.8	23.1	76.9
28	589	47.2	14.8	37.9	62.1
35	417	53.2	16.7	54.7	45.3
48	295	49.9	15.7	70.4	29.6
65	208	30.4	9.6	79.9	20.1
100	147	17.5	5.5	85.4	14.6
150	104	11.1	3.5	88.9	11.1
200	74	7.4	2.3	91.2	8.8
270	53	4.9	1.5	92.8	7.2
400	37	3.7	1.2	93.9	6.1
Pan	-37	19.3	6.1	100.0	-
Total	-	**318.1**	**100.0**	-	-
K80	**922**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	16.4	15.6	15.6	84.4
100	147	16.7	15.9	31.6	68.4
150	104	12.5	11.9	43.5	56.5
200	74	10.3	9.8	53.3	46.7
270	53	8.0	7.6	60.9	39.1
400	37	6.7	6.4	67.3	32.7
Pan	-37	34.3	32.7	100.0	-
Total	-	**104.9**	**100.0**	-	-
K80	**192**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	6.6	8.6	8.6	91.4
100	147	12.1	15.8	24.4	75.6
150	104	8.4	11.0	35.4	64.6
200	74	6.3	8.2	43.6	56.4
270	53	6.0	7.8	51.4	48.6
400	37	5.4	7.0	58.5	41.5
Pan	-37	31.8	41.5	100.0	-
Total	-	**76.6**	**100.0**	-	-
K80	**166**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
	Insufficient Sample				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	10.2	7.3	7.3	92.7
100	147	21.2	15.3	22.6	77.4
150	104	19.0	13.7	36.3	63.7
200	74	15.9	11.4	47.7	52.3
270	53	13.9	10.0	57.7	42.3
400	37	11.0	7.9	65.6	34.4
Pan	-37	47.8	34.4	100.0	-
Total	-	**139.0**	**100.0**	-	-
K80	**157**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 μm aperture)

C L R
1123%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	42.1	82.5	86.0	0.0
-48+100	15.6	11.9	10.5	31.6
-100+200	12.5	1.8	1.1	21.7
-200+400	10.2	0.8	0.3	14.0
-400	19.5	3.0	2.1	32.7

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	1182 %	79.3	938 %
-48+100	1120 %	12.2	137 %
-100+200	1326 %	2.6	34 %
-200+400	732 %	1.9	14 %
-400	1421 %	4.0	56 %
Total		100.0	1123 %

Test No. PP-36

1. **Purpose:** To duplicate the conditions of test PP-35.

2. **Procedure:** All process units started, including unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		69.5 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.29	0.62	3.14	1.79	6.60
Unit Column	Grade	7.97	6.11	20.5	17.7	2.59
	Recov	39.7	63.8	42.0	63.8	0.75
Primary Rougher	Grade	4.60	1.85	11.58	5.35	4.59
	Recov	28.6	24.1	29.6	24.1	3.23
Secondary Rougher	Grade	2.97	0.81	7.12	2.34	7.92
	Recov	1.6	0.9	1.5	0.9	0.31
Scavenger	Grade	1.46	0.17	2.95	0.49	20.3
	Recov	22.6	5.5	18.8	5.5	9.91
Overall Circuit	Grade	3.40	1.65	8.22	4.79	6.93
	Recov	92.4	94.2	91.9	94.2	14.20

Detailed chemical size analyses were conducted on all sampled products in order to determine the size-by-size distribution of solids and metals around the circuit.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	193.3 kg/h of -1/4 inch feed (Wet Sple 1164.1 g)
	(Dry Sple 1150.7 g)
Feed Rate:	191.1 kg/h of dry ore. (Moisture 1.15 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 837 kg in 4.33 hr
	Sample 387 kg in 2.00 hr
Rod Mill Discharge:	1,698 g/L (58 % Sol at Solid SG of 3.39)
	41.0 % plus 48 mesh
	42.1 % minus 100 mesh
Input Power:	33.08 for 3 disc revolutions
	1.18 kW (95% drive efficiency)
Average Power:	1.12 kW Gross
	0.47 kW No Load
	0.64 kW Net
Net Power Usage:	3.36 kWh/tonne of -1/4 inch feed.
K80 Feed:	3,932 microns
K80 Product:	629 microns
Work Index (metric):	14.1

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 277 % circ. load)
Feed Rate:	530.0 kg/h
Mill Speed:	41 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,174 g/L (21 % Sol at S' 3.39)
Ball Mill Discharge:	1,592 g/L (53 % Sol at S' 3.39)
	81.3 % plus 48 mesh
	5.3 % minus 100 mesh
Input Power:	25.19 for 3 disc revolutions
	1.54 kW (95% drive efficiency)
Average Power:	1.47 kW Gross
	0.52 kW No Load
	0.94 kW Net
Net Power Usage:	1.78 kWh/tonne of screen oversize.
K80 Feed:	629 microns
K80 Product:	185 microns
Work Index (metric):	5.3

3.1.3. Overall Mill Report:

Net Power Usage:	5.14 kWh/t
K80 Feed:	3,932 microns
K80 Product:	185 microns
Work Index (metric):	8.9
Screen Undersize:	69.5 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	3,932	20.2
Rod Mill Discharge	629	42.1
Ball Mill Feed	940	2.3
Ball Mill Discharge	936	5.3
Column Feed	868	16.3
Column Conc	102	89.1
Screen Feed	999	19.8
Screen Undersize	185	69.5
Prim Rghr Conc	164	76.1
Sec Rghr Conc	60	93.1
Scavenger Tail	172	72.9

3.2. Reagent Additions:

Average Feed Rate: 0.191 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Column Feed	NaIX	2.0%	3.0	18.8
	DF-250	2.0%	4.9	30.8
Rougher Feed	NaIX	2.0%	5.1	32.0
	DF-250	2.0%	2.9	18.2
Scavenger 1 Feed	NaIX	2.0%	7.0	44.0
	DF-250	2.0%	1.9	11.9
	CuSO4	2.0%	6.2	38.9
Scavenger 2 Feed	NaIX	2.0%	5.0	31.4
	DF-250	2.0%	4.1	25.7
Total	**NaIX**		20.1	**126.2**
	DF-250		13.8	**86.7**
	CuSO4		6.2	**38.9**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,698			3.39
Ball Mill Discharge	1,592			
Screen Feed	1,512	9.80		
Screen Undersize	1,174	9.40	24.7	
Scavenger 1 Feed	1,122	8.40		
Scavenger 2 Tail	1,250			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	721	1.51	16.5	2.5
Primary Rougher	56	179	1.51	4.1	13.6
Secondary Rougher	28	163	1.12	15.7	1.8
Scavenger	336	162	1.25	7.6	44.1
Total	420				59.5

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 484%** **From BILCO 277%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.29	0.59	10.20	1.29	0.62	9.94	191.1	100.00
Rod Mill Discharge	1.28	0.66	9.7	1.29	0.62	9.94	191.1	100.00
Ball Mill Feed	0.36	0.27	4.27	0.38	0.29	3.99	530.0	277.35
Ball Mill Discharge	0.39	0.30	4.67	0.38	0.29	3.99	530.0	277.35
Unit Column Feed	0.64	0.42	6.04	0.62	0.39	5.59	721.1	377.35
Unit Column Conc	7.96	6.12	34.00	7.97	6.11	34.3	12.3	6.43
Screen Feed	0.48	0.34	3.83	0.49	0.30	4.85	708.8	370.92
Screen Undersize	0.86	0.23	9.4	0.83	0.24	8.27	178.8	93.57
Prim Rghr Conc	4.54	1.87	26.8	4.60	1.85	26.9	15.3	8.03
Prim Rghr Tail	0.49	0.08	6.34	0.48	0.09	6.52	163.5	85.54
Sec Rghr Conc	2.96	0.81	25.5	2.97	0.81	25.7	1.3	0.68
Sec Rghr Tail	0.46	0.080	7.18	0.46	0.082	6.36	162.2	84.86
Scavenger Conc	1.42	0.180	23.3	1.46	0.170	24.9	38.2	20.00
Scavenger Tail	0.15	0.058	0.63	0.15	0.055	0.63	123.9	64.85

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.29	0.62	9.9	3.14	20.7	1.79	6.6
Combined Conc	35.1	3.40	1.65	27.1	8.22	57.0	4.79	6.9
Final Tail	64.9	0.15	0.06	0.63	0.39	1.1	0.16	2.9
Unit Column Feed	377.4	0.62	0.39	5.59	1.46	11.8	1.14	8.1
Unit Column Conc	6.4	7.97	6.11	34.28	20.50	53.1	17.70	2.6
Unit Column Tail	370.9	0.49	0.30	4.85	1.14	10.4	0.87	9.2
Prim Rghr Feed	93.6	0.83	0.24	8.27	1.95	18.5	0.69	9.5
Prim Rghr Conc	8.0	4.60	1.85	26.9	11.58	53.1	5.35	4.6
Prim Rghr Tail	85.5	0.48	0.09	6.52	1.04	15.3	0.25	14.6
Sec Rghr Feed	85.5	0.48	0.09	6.52	1.04	15.3	0.25	14.6
Sec Rghr Conc	0.7	2.97	0.81	25.7	7.12	56.4	2.34	7.9
Sec Rghr Tail	84.9	0.46	0.08	6.36	1.00	14.9	0.24	15.0
Comb Rghr Feed	93.6	0.83	0.24	8.27	1.95	18.5	0.69	9.5
Comb Rghr Conc	8.7	4.47	1.76	26.8	11.23	53.4	5.12	4.8
Comb Rghr Tail	84.9	0.46	0.08	6.36	1.00	14.9	0.24	15.0
Scavenger Feed	84.9	0.46	0.08	6.36	1.00	14.9	0.24	15.0
Scavenger Conc	20.0	1.46	0.17	24.9	2.95	59.7	0.49	20.3
Scavenger Tail	64.9	0.15	0.06	0.63	0.39	1.1	0.16	2.9
Comb Mech Feed	93.6	0.83	0.24	8.27	1.95	18.5	0.69	9.5
Comb Mech Conc	28.7	2.37	0.65	25.5	5.47	57.8	1.89	10.6
Comb Mech Tail	64.9	0.15	0.06	0.63	0.39	1.1	0.16	2.9
Col + P.Rghr Feed	100.0	1.29	0.62	9.9	3.14	20.7	1.79	6.6
Col + P.Rghr Conc	14.5	6.10	3.74	30.2	15.6	53.1	10.9	3.4
Col + P.Rghr Tail	85.5	0.48	0.09	6.5	1.04	15.3	0.25	14.6

4.3. Metallurgical Balance - Distributions:

Product	Overall Wt %	Metal Distributions (%) Ni	Cu	S(T)	Mineral Distributions (%) Pn	Po	Cp	Gangue Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	35.1	92.4	94.2	95.9	91.9	96.5	94.2	14.2
Final Tail	64.9	7.6	5.8	4.1	8.1	3.5	5.8	85.8
Unit Column Feed	377.4	180.2	240.1	212.1	175.1	214.6	240.1	434.6
Unit Column Conc	6.4	39.7	63.8	22.2	42.0	16.5	63.8	0.8
Unit Column Tail	370.9	140.5	176.4	189.9	133.2	198.2	176.4	433.9
Prim Rghr Feed	93.6	60.3	36.2	77.8	58.1	83.5	36.2	99.2
Prim Rghr Conc	8.0	28.6	24.1	21.7	29.6	20.6	24.1	3.2
Prim Rghr Tail	85.5	31.7	12.1	56.1	28.5	63.0	12.1	96.0
Sec Rghr Feed	85.5	31.7	12.1	56.1	28.4	63.0	12.1	96.0
Sec Rghr Conc	0.7	1.6	0.9	1.8	1.5	1.8	0.9	0.3
Sec Rghr Tail	84.9	30.2	11.2	54.3	26.9	61.1	11.2	95.7
Comb Rghr Feed	93.6	60.3	36.2	77.8	58.1	83.5	36.2	99.2
Comb Rghr Conc	8.7	30.1	25.0	23.5	31.1	22.4	25.0	3.5
Comb Rghr Tail	84.9	30.2	11.2	54.3	26.9	61.1	11.2	95.7
Scavenger Feed	84.9	30.1	11.3	54.3	26.9	61.1	11.3	95.7
Scavenger Conc	20.0	22.6	5.5	50.2	18.8	57.6	5.5	9.9
Scavenger Tail	64.9	7.6	5.8	4.1	8.1	3.5	5.8	85.8
Comb Mech Feed	93.6	60.3	36.2	77.8	58.1	83.5	36.2	99.2
Comb Mech Conc	28.7	52.7	30.4	73.7	50.0	80.0	30.4	13.5
Comb Mech Tail	64.9	7.6	5.8	4.1	8.1	3.5	5.8	85.8
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.5	68.3	87.9	43.9	71.6	37.0	87.9	4.0
Col + P.Rghr Tail	85.5	31.7	12.1	56.1	28.4	63.0	12.1	96.0

4.4. Individual Unit Performance - Distributions:

Product	Individual	Metal Distributions			Mineral Distributions			
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	35.1	92.4	94.2	95.9	91.9	96.5	94.2	14.2
Final Tail	64.9	7.6	5.8	4.1	8.1	3.5	5.8	85.8
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	1.7	22.0	26.6	10.5	24.0	7.7	26.6	0.2
Unit Column Tail	98.3	78.0	73.4	89.5	76.0	92.3	73.4	99.8
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	8.6	47.4	66.6	27.9	51.0	24.6	66.6	3.3
Prim Rghr Tail	91.4	52.6	33.4	72.1	49.0	75.4	33.4	96.7
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	0.8	4.9	7.4	3.1	5.4	2.9	7.4	0.3
Sec Rghr Tail	99.2	95.1	92.6	96.9	94.6	97.1	92.6	99.7
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	9.3	50.0	69.0	30.2	53.6	26.8	69.0	3.6
Comb Rghr Tail	90.7	50.0	31.0	69.8	46.4	73.2	31.0	96.4
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	23.6	74.8	48.9	92.4	69.9	94.3	48.9	10.4
Scavenger Tail	76.4	25.2	51.1	7.6	30.1	5.7	51.1	89.6
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	30.7	87.4	84.0	94.7	86.1	95.8	84.0	13.6
Comb Mech Tail	69.3	12.6	16.0	5.3	13.9	4.2	16.0	86.4
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.5	68.3	87.9	43.9	71.6	37.0	87.9	4.0
Col + P.Rghr Tail	85.5	31.7	12.1	56.1	28.4	63.0	12.1	96.0

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	117.2	12.7	12.7	87.3
6	3,327	124.1	13.5	26.2	73.8
8	2,362	94.9	10.3	36.5	63.5
10	1,651	92.6	10.1	46.6	53.4
14	1,168	67.7	7.4	53.9	46.1
20	833	49.8	5.4	59.4	40.6
28	589	45.6	5.0	64.3	35.7
35	417	41.5	4.5	68.8	31.2
48	295	34.2	3.7	72.5	27.5
65	208	33.5	3.6	76.2	23.8
100	147	33.4	3.6	79.8	20.2
150	104	28.7	3.1	82.9	17.1
200	74	26.5	2.9	85.8	14.2
270	53	23.8	2.6	88.4	11.6
400	37	18.0	2.0	90.3	9.7
Pan	-37	88.9	9.7	100.0	-
Total	-	**920.4**	**100.0**	-	-
K80	**3,932**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.9	0.7	0.7	99.3
14	1,168	11.7	2.9	3.6	96.4
20	833	30.1	7.4	11.0	89.0
28	589	43.8	10.8	21.7	78.3
35	417	42.8	10.5	32.2	67.8
48	295	35.8	8.8	41.0	59.0
65	208	34.4	8.4	49.5	50.5
100	147	34.1	8.4	57.9	42.1
150	104	27.8	6.8	64.7	35.3
200	74	24.6	6.0	70.7	29.3
270	53	24.9	6.1	76.8	23.2
400	37	18.7	4.6	81.4	18.6
Pan	-37	75.6	18.6	100.0	-
Total	-	**407.2**	**100.0**	-	-
K80	**629**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.3	1.9	1.9	98.1
14	1,168	33.0	9.7	11.6	88.4
20	833	44.1	13.0	24.5	75.5
28	589	62.7	18.4	42.9	57.1
35	417	73.5	21.6	64.6	35.4
48	295	70.9	20.8	85.4	14.6
65	208	32.5	9.6	94.9	5.1
100	147	9.5	2.8	97.7	2.3
150	104	3.6	1.1	98.8	1.2
200	74	1.5	0.4	99.2	0.8
270	53	0.7	0.2	99.4	0.6
400	37	0.5	0.1	99.6	0.4
Pan	-37	1.4	0.4	100.0	-
Total	-	**340.2**	**100.0**	-	-
K80	**940**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	15.6	4.0	4.0	96.0
14	1,168	30.4	7.7	11.6	88.4
20	833	49.3	12.5	24.1	75.9
28	589	71.8	18.2	42.3	57.7
35	417	81.9	20.7	63.1	36.9
48	295	72.1	18.3	81.3	18.7
65	208	39.9	10.1	91.4	8.6
100	147	12.9	3.3	94.7	5.3
150	104	5.9	1.5	96.2	3.8
200	74	3.6	0.9	97.1	2.9
270	53	2.5	0.6	97.7	2.3
400	37	1.8	0.5	98.2	1.8
Pan	-37	7.2	1.8	100.0	-
Total	-	**394.9**	**100.0**	-	-
K80	**936**				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	8.5	1.9	1.9	98.1
14	1,168	33.4	7.6	9.6	90.4
20	833	50.1	11.4	21.0	79.0
28	589	69.1	15.8	36.8	63.2
35	417	76.5	17.5	54.2	45.8
48	295	69.4	15.8	70.0	30.0
65	208	40.0	9.1	79.2	20.8
100	147	19.9	4.5	83.7	16.3
150	104	12.4	2.8	86.5	13.5
200	74	10.4	2.4	88.9	11.1
270	53	8.8	2.0	90.9	9.1
400	37	6.5	1.5	92.4	7.6
Pan	-37	33.3	7.6	100.0	-
Total	-	**438.3**	**100.0**	-	-
K80	**868**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	9.2	5.1	5.1	94.9
100	147	10.6	5.8	10.9	89.1
150	104	15.8	8.7	19.6	80.4
200	74	20.8	11.4	31.0	69.0
270	53	22.0	12.1	43.1	56.9
400	37	21.7	11.9	55.1	44.9
Pan	-37	81.6	44.9	100.0	-
Total	-	**181.7**	**100.0**	-	-
K80	**102**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	7.4	2.2	2.2	97.8
14	1,168	38.9	11.6	13.8	86.2
20	833	45.0	13.4	27.2	72.8
28	589	52.5	15.6	42.8	57.2
35	417	50.9	15.1	57.9	42.1
48	295	41.0	12.2	70.1	29.9
65	208	22.1	6.6	76.7	23.3
100	147	11.9	3.5	80.2	19.8
150	104	8.8	2.6	82.8	17.2
200	74	8.4	2.5	85.3	14.7
270	53	7.5	2.2	87.6	12.4
400	37	6.2	1.8	89.4	10.6
Pan	-37	35.6	10.6	100.0	-
Total	-	**336.2**	**100.0**	-	-
K80	**999**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	32.1	13.8	13.8	86.2
100	147	38.9	16.7	30.5	69.5
150	104	31.1	13.4	43.9	56.1
200	74	26.6	11.4	55.3	44.7
270	53	20.9	9.0	64.3	35.7
400	37	15.8	6.8	71.1	28.9
Pan	-37	67.2	28.9	100.0	-
Total	-	**232.6**	**100.0**	-	-
K80	**185**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	13.9	8.6	8.6	91.4
100	147	24.6	15.3	23.9	76.1
150	104	16.8	10.4	34.3	65.7
200	74	12.7	7.9	42.2	57.8
270	53	12.8	7.9	50.2	49.8
400	37	11.6	7.2	57.4	42.6
Pan	-37	68.7	42.6	100.0	-
Total	-	**161.1**	**100.0**	-	-
K80	**164**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	9.4	4.0	4.0	96.0
100	147	6.9	2.9	6.9	93.1
150	104	6.6	2.8	9.6	90.4
200	74	12.4	5.2	14.8	85.2
270	53	19.2	8.1	22.9	77.1
400	37	18.7	7.9	30.8	69.2
Pan	-37	164.7	69.2	100.0	-
Total	-	**237.9**	**100.0**	-	-
K80	**60**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	25.6	9.6	9.6	90.4
100	147	46.6	17.5	27.1	72.9
150	104	35.5	13.3	40.4	59.6
200	74	28.7	10.8	51.2	48.8
270	53	26.3	9.9	61.1	38.9
400	37	17.3	6.5	67.6	32.4
Pan	-37	86.3	32.4	100.0	-
Total	-	**266.3**	**100.0**	-	-
K80	**172**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 μm aperture)

C L R
1021%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	41.0	81.3	85.4	0.0
-48+100	16.8	13.4	12.3	30.5
-100+200	12.9	2.4	1.5	24.8
-200+400	10.7	1.1	0.4	15.8
-400	18.6	1.8	0.4	28.9

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	1006 %	77.7	781 %
-48+100	1337 %	13.6	182 %
-100+200	1317 %	3.1	41 %
-200+400	689 %	2.3	16 %
-400	731 %	3.3	24 %
Total		100.0	**1021 %**

Rod Mill Feed

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni		% Ret Cuml.	Assay %Cu		% Ret Cuml.	Assay %S		% Ret Cuml.
				Indiv.	Cuml.		Indiv.	Cuml.		Indiv.	Cuml.	
4,699	117.2	12.7	12.7	0.59	0.59	5.8	0.55	0.55	11.9	5.68	5.68	7.1
3,327	124.1	13.5	26.2	0.66	0.63	12.7	0.45	0.50	22.2	5.63	5.65	14.5
2,362	94.9	10.3	36.5	0.83	0.68	19.4	0.54	0.51	31.6	6.83	5.99	21.4
1,651	92.6	10.1	46.6	0.80	0.71	25.6	0.50	0.51	40.1	7.00	6.21	28.3
1,168	67.7	7.4	53.9	0.87	0.73	30.6	0.58	0.52	47.3	8.43	6.51	34.4
833	49.8	5.4	59.4	1.01	0.76	34.8	0.62	0.53	53.0	10.4	6.86	39.9
589	45.6	5.0	64.3	1.09	0.78	39.0	0.62	0.53	58.2	12.6	7.31	46.1
417	41.5	4.5	68.8	1.22	0.81	43.2	0.65	0.54	63.2	14.3	7.76	52.4
295	34.2	3.7	72.5	1.39	0.84	47.2	0.73	0.55	67.8	15.6	8.16	58.1
208	33.5	3.6	76.2	1.76	0.88	52.2	0.74	0.56	72.4	17.4	8.61	64.3
147	33.4	3.6	79.8	2.37	0.95	58.9	0.85	0.57	77.6	17.7	9.02	70.6
104	28.7	3.1	82.9	3.10	1.03	66.4	0.97	0.59	82.7	17.6	9.34	75.9
74	26.5	2.9	85.8	3.46	1.11	74.1	1.07	0.60	87.9	16.6	9.59	80.6
53	23.8	2.6	88.4	3.49	1.18	81.1	1.06	0.62	92.6	17.4	9.81	85.0
37	18.0	2.0	90.3	3.59	1.24	86.5	1.18	0.63	96.5	16.7	10.0	88.2
-37	88.9	9.7	100.0	(1.80)	1.29	100.0	(0.21)	0.59	100.0	(12.4)	10.2	100.0
Total	**920.4**	**100.0**	--	**1.29**	--	--	**0.59**	--	--	**10.2**	--	--

Rod Mill Discharge

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni		% Ret Cuml.	Assay %Cu		% Ret Cuml.	Assay %S		% Ret Cuml.
				Indiv.	Cuml.		Indiv.	Cuml.		Indiv.	Cuml.	
1,651	0.0	0.0	0.0	0.00	--	0.0	0.00	--	0.0	0.00	--	0.0
1,168	14.6	3.6	3.6	0.24	0.24	0.7	0.30	0.30	1.6	2.25	2.25	0.8
833	30.1	7.4	11.0	0.39	0.34	2.9	0.40	0.37	6.1	3.40	3.02	3.4
589	43.8	10.8	21.7	0.46	0.40	6.8	0.45	0.41	13.4	5.11	4.06	9.1
417	42.8	10.5	32.2	0.63	0.47	12.0	0.46	0.43	20.8	7.25	5.10	16.9
295	35.8	8.8	41.0	0.70	0.52	16.8	0.47	0.43	27.0	8.83	5.90	24.9
208	34.4	8.4	49.5	0.94	0.59	23.0	0.53	0.45	33.8	10.8	6.73	34.4
147	34.1	8.4	57.9	1.34	0.70	31.7	0.65	0.48	42.1	11.8	7.47	44.5
104	27.8	6.8	64.7	1.75	0.81	41.1	0.69	0.50	49.2	12.7	8.02	53.5
74	24.6	6.0	70.7	2.14	0.93	51.2	0.79	0.53	56.4	13.6	8.50	62.0
53	24.9	6.1	76.8	2.21	1.03	61.7	0.82	0.55	64.0	14.0	8.93	70.8
37	18.7	4.6	81.4	2.37	1.10	70.2	0.93	0.57	70.5	13.8	9.21	77.3
-37	75.6	18.6	100.0	(2.05)	1.28	100.0	(1.05)	0.66	100.0	(11.9)	9.70	100.0
Total	**407.2**	**100.0**	--	**1.28**	--	--	**0.66**	--	--	**9.70**	--	--

Ball Mill Feed

Particle	Solids			Nickel			Copper			Sulphur		
Size	Weight	% Ret.	% Ret	Assay %Ni		% Ret	Assay %Cu		% Ret	Assay %S		% Ret
µm	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
1,651	6.3	1.9	1.9	0.20	0.20	1.1	0.19	0.19	1.1	1.72	1.72	0.7
1,168	33.0	9.7	11.6	0.19	0.19	6.6	0.31	0.29	10.6	1.89	1.86	4.9
833	44.1	13.0	24.5	0.22	0.21	15.0	0.33	0.31	24.1	2.24	2.06	11.5
589	62.7	18.4	42.9	0.26	0.23	29.2	0.33	0.32	43.3	3.21	2.55	24.9
417	73.5	21.6	64.6	0.30	0.25	48.4	0.32	0.32	65.1	4.30	3.14	45.9
295	70.9	20.8	85.4	0.38	0.28	71.8	0.32	0.32	86.2	5.37	3.68	71.3
208	32.5	9.6	94.9	0.55	0.31	87.4	0.31	0.32	95.5	7.98	4.12	88.6
147	9.5	2.8	97.7	0.84	0.33	94.3	0.27	0.32	97.9	10.4	4.30	95.1
-147	7.7	2.3	100.0	0.85	0.34	100.0	0.29	0.32	100.0	9.46	4.41	100.0
Total	**340.2**	**100.0**	--	**0.34**	--	--	**0.32**	--	--	**4.41**	--	--
Direct				**0.36**			**0.27**			**4.27**		

Ball Mill Discharge

Particle	Solids			Nickel			Copper			Sulphur		
Size	Weight	% Ret.	% Ret	Assay %Ni		% Ret	Assay %Cu		% Ret	Assay %S		% Ret
µm	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
1,651	15.6	4.0	4.0	0.17	0.17	2.0	0.27	0.27	3.4	1.40	1.40	1.3
1,168	30.4	7.7	11.6	0.18	0.18	6.0	0.28	0.28	10.3	1.79	1.66	4.6
833	49.3	12.5	24.1	0.21	0.19	13.7	0.26	0.27	20.7	2.05	1.86	10.7
589	71.8	18.2	42.3	0.24	0.21	26.5	0.29	0.28	37.6	2.62	2.19	22.0
417	81.9	20.7	63.1	0.28	0.24	43.6	0.32	0.29	58.8	3.86	2.74	41.0
295	72.1	18.3	81.3	0.36	0.26	62.8	0.33	0.30	78.1	5.22	3.29	63.6
208	39.9	10.1	91.4	0.48	0.29	77.1	0.35	0.31	89.4	7.16	3.72	80.8
147	12.9	3.3	94.7	0.75	0.30	84.2	0.33	0.31	92.9	9.6	3.93	88.2
-147	21.0	5.3	100.0	1.01	0.34	100.0	0.42	0.31	100.0	9.32	4.21	100.0
Total	**394.9**	**100.0**	--	**0.34**	--	--	**0.31**	--	--	**4.21**	--	--
Direct				**0.39**			**0.30**			**4.67**		

Unit Column Feed

Particle	Solids			Nickel			Copper			Sulphur		
Size	Weight	% Ret.	% Ret	Assay %Ni		% Ret	Assay %Cu		% Ret	Assay %S		% Ret
µm	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
1,651	8.5	1.9	1.9	0.17	0.17	0.6	0.29	0.29	1.4	1.55	1.6	0.5
1,168	33.4	7.6	9.6	0.21	0.20	3.3	0.31	0.31	7.3	1.87	1.8	3.1
833	50.1	11.4	21.0	0.25	0.23	8.2	0.31	0.31	16.1	2.34	2.1	7.8
589	69.1	15.8	36.8	0.29	0.25	16.0	0.34	0.32	29.5	3.00	2.5	16.2
417	76.5	17.5	54.2	0.34	0.28	26.1	0.32	0.32	43.4	4.27	3.1	29.5
295	69.4	15.8	70.0	0.39	0.31	36.7	0.31	0.32	55.6	5.91	3.7	46.1
208	40.0	9.1	79.2	0.61	0.34	46.2	0.39	0.33	64.5	8.12	4.2	59.3
147	19.9	4.5	83.7	1.13	0.38	54.9	0.48	0.34	69.9	11.5	4.6	68.5
104	12.4	2.8	86.5	1.52	0.42	62.3	0.60	0.34	74.1	12.6	4.9	74.9
74	10.4	2.4	88.9	1.82	0.46	69.6	0.68	0.35	78.2	12.9	5.1	80.3
53	8.8	2.0	90.9	1.97	0.49	76.4	0.72	0.36	81.8	13.2	5.3	85.0
37	6.5	1.5	92.4	2.00	0.52	81.5	0.79	0.37	84.7	12.8	5.4	88.4
-37	33.3	7.6	100.0	1.43	0.59	100.0	0.81	0.40	100.0	8.61	5.6	100.0
Total	**438.3**	**100.0**	--	**0.59**	--	--	**0.40**	--	--	**5.63**	--	--
Direct				**0.64**			**0.42**			**6.04**		

Unit Column Concentrate

Particle	Solids			Nickel			Copper			Sulphur		
Size	Weight	% Ret.	% Ret	Assay %Ni		% Ret	Assay %Cu		% Ret	Assay %S		% Ret
µm	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
208	9.2	5.1	5.1	2.83	2.83	1.8	6.96	6.96	5.8	41.2	41.2	6.3
147	10.6	5.8	10.9	7.37	5.26	7.2	8.03	7.53	13.5	33.7	37.2	12.2
104	15.8	8.7	19.6	10.6	7.63	18.7	7.17	7.37	23.7	33.2	35.4	20.9
74	20.8	11.4	31.0	11.1	8.91	34.6	6.22	6.95	35.4	33.6	34.7	32.5
53	22.0	12.1	43.1	11.3	9.58	51.6	6.00	6.68	47.3	32.7	34.2	44.4
37	21.7	11.9	55.1	10.0	9.67	66.6	5.52	6.43	58.1	33.6	34.0	56.5
-37	81.6	44.9	100.0	5.96	8.00	100.0	5.69	6.10	100.0	32.2	33.2	100.0
Total	**181.7**	**100.0**	--	**8.00**	--	--	**6.10**	--	--	**33.2**	--	--
Direct				**7.96**			**6.12**			**34.0**		

Unit Column Tail (Screen Feed)

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni		% Ret Cuml.	Assay %Cu		% Ret Cuml.	Assay %S		% Ret Cuml.
				Indiv.	Cuml.		Indiv.	Cuml.		Indiv.	Cuml.	
1,651	7.4	2.2	2.2	0.11	0.11	0.7	0.27	0.27	2.2	1.08	1.08	0.6
1,168	38.9	11.6	13.8	0.17	0.16	6.1	0.26	0.26	13.3	1.54	1.47	5.5
833	45.0	13.4	27.2	0.19	0.17	13.2	0.29	0.28	27.7	1.89	1.68	12.4
589	52.5	15.6	42.8	0.23	0.20	23.2	0.30	0.28	45.0	2.39	1.94	22.6
417	50.9	15.1	57.9	0.24	0.21	33.2	0.29	0.29	61.2	3.13	2.25	35.5
295	41.0	12.2	70.1	0.30	0.22	43.4	0.27	0.28	73.4	4.31	2.61	49.8
208	22.1	6.6	76.7	0.42	0.24	51.1	0.28	0.28	80.2	5.83	2.88	60.2
147	11.9	3.5	80.2	0.58	0.25	56.8	0.24	0.28	83.4	6.98	3.06	67.0
104	8.8	2.6	82.8	0.61	0.27	61.2	0.19	0.28	85.2	7.30	3.20	72.2
74	8.4	2.5	85.3	0.64	0.28	65.6	0.14	0.27	86.5	7.77	3.33	77.5
53	7.5	2.2	87.6	0.71	0.29	70.0	0.12	0.27	87.5	8.67	3.47	82.7
37	6.2	1.8	89.4	0.80	0.30	74.1	0.11	0.27	88.3	8.51	3.57	87.0
-37	35.6	10.6	100.0	0.88	0.36	100.0	0.30	0.27	100.0	4.50	3.67	100.0
Total	**336.2**	**100.0**	--	**0.36**	--	--	**0.27**	--	--	**3.67**	--	--
Direct				**0.48**			**0.34**			**3.83**		

Screen Undersize (Flotation Feed)

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni		% Ret Cuml.	Assay %Cu		% Ret Cuml.	Assay %S		% Ret Cuml.
				Indiv.	Cuml.		Indiv.	Cuml.		Indiv.	Cuml.	
208	32.1	13.8	13.8	0.78	0.78	12.4	0.35	0.35	21.4	9.15	9.15	13.9
147	38.9	16.7	30.5	0.82	0.80	28.3	0.29	0.32	42.9	10.2	9.73	32.7
104	31.1	13.4	43.9	0.9	0.84	42.6	0.18	0.28	53.5	10.4	9.93	48.1
74	26.6	11.4	55.3	0.9	0.84	54.0	0.14	0.25	60.6	10.6	10.1	61.5
53	20.9	9.0	64.3	0.9	0.85	63.3	0.11	0.23	65.0	10.9	10.2	72.3
37	15.8	6.8	71.1	0.9	0.86	70.6	0.10	0.22	68.0	10.3	10.2	80.0
-37	67.2	28.9	100.0	0.88	0.87	100.0	0.25	0.23	100.0	6.28	9.06	100.0
Total	**232.6**	**100.0**	--	**0.87**	--	--	**0.23**	--	--	**9.06**	--	--
Direct				**0.86**			**0.23**			**9.40**		

Primary Rougher Concentrate

Particle	Solids			Nickel			Copper			Sulphur		
Size	Weight	% Ret.	% Ret	Assay %Ni		% Ret	Assay %Cu		% Ret	Assay %S		% Ret
µm	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
208	13.9	8.6	8.6	3.20	3.20	6.1	3.75	3.75	17.6	21.9	21.9	7.0
147	24.6	15.3	23.9	4.26	3.88	20.6	2.50	2.95	38.3	26.0	24.5	21.6
104	16.8	10.4	34.3	6.34	4.63	35.3	2.24	2.74	51.0	28.0	25.6	32.3
74	12.7	7.9	42.2	6.83	5.04	47.3	1.72	2.55	58.4	28.4	26.1	40.6
53	12.8	7.9	50.2	6.36	5.25	58.5	1.20	2.33	63.6	32.6	27.1	50.1
37	11.6	7.2	57.4	4.81	5.19	66.2	0.77	2.14	66.6	34.0	28.0	59.2
-37	68.7	42.6	100.0	3.56	4.50	100.0	1.44	1.84	100.0	26.0	27.1	100.0
Total	**161.1**	**100.0**	--	**4.50**	--	--	**1.84**	--	--	**27.1**	--	--
Direct				**4.54**			**1.87**			**26.8**		

Secondary Rougher Concentrate

Particle	Solids			Nickel			Copper			Sulphur		
Size	Weight	% Ret.	% Ret	Assay %Ni		% Ret	Assay %Cu		% Ret	Assay %S		% Ret
µm	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
208	9.4	4.0	4.0	1.33	1.33	1.8	0.80	0.80	3.7	11.7	11.7	1.9
147	6.9	2.9	6.9	2.67	1.90	4.5	1.01	0.89	7.1	22.1	16.1	4.6
104	6.6	2.8	9.6	3.04	2.23	7.5	0.67	0.83	9.2	27.1	19.3	7.8
74	12.4	5.2	14.8	3.31	2.61	13.5	0.45	0.69	11.9	27.6	22.2	13.8
53	19.2	8.1	22.9	2.30	2.50	19.9	0.34	0.57	15.1	27.9	24.2	23.3
37	18.7	7.9	30.8	3.36	2.72	29.1	0.25	0.49	17.4	29.0	25.4	32.9
-37	164.7	69.2	100.0	2.94	2.87	100.0	1.03	0.86	100.0	23.1	23.8	100.0
Total	**237.9**	**100.0**	--	**2.87**	--	--	**0.86**	--	--	**23.8**	--	--
Direct				**2.96**			**0.81**			**25.5**		

Scavenger Tail

Particle	Solids			Nickel			Copper			Sulphur		
Size	Weight	% Ret.	% Ret	Assay %Ni		% Ret	Assay %Cu		% Ret	Assay %S		% Ret
µm	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
208	25.6	9.6	9.6	0.110	0.110	7.4	0.110	0.110	20.2	1.13	1.13	16.9
147	46.6	17.5	27.1	0.097	0.102	19.2	0.073	0.086	44.6	0.93	1.00	42.3
104	35.5	13.3	40.4	0.087	0.097	27.2	0.055	0.076	58.6	0.93	0.98	61.6
74	28.7	10.8	51.2	0.074	0.092	32.8	0.039	0.068	66.6	0.56	0.89	71.0
53	26.3	9.9	61.1	0.073	0.089	37.8	0.026	0.061	71.5	0.28	0.79	75.3
37	17.3	6.5	67.6	0.080	0.088	41.4	0.020	0.057	74.0	0.19	0.73	77.3
-37	86.3	32.4	100.0	0.260	0.144	100.0	0.042	0.052	100.0	0.45	0.64	100.0
Total	**266.3**	**100.0**	--	**0.144**	--	--	**0.052**	--	--	**0.64**	--	--
Direct				**0.150**			**0.058**			**0.63**		

Test No. PP-36

Unit Column Concentrate 12.30 kg/h 1.71% mass fraction

Particle	Solids			Nickel			Copper			Sulphur		
Size	% Ret.	Rate	% Ret.	Assay	Distribution		Assay	Distribution		Assay	Distribution	
µm	Indiv.	kg/h	Cuml.	%Ni	Indiv.	Cuml.	%Cu	Indiv.	Cuml.	%S	Indiv.	Cuml.
208	5.1	0.6	5.1	2.83	1.8	1.8	6.96	5.8	5.8	41.2	6.3	6.3
147	5.8	0.7	10.9	7.37	5.4	7.2	8.03	7.7	13.5	33.7	5.9	12.2
104	8.7	1.1	19.6	10.6	11.5	18.7	7.17	10.2	23.7	33.2	8.7	20.9
74	11.4	1.4	31.0	11.1	15.9	34.6	6.22	11.7	35.4	33.6	11.6	32.5
53	12.1	1.5	43.1	11.3	17.1	51.6	6.00	11.9	47.3	32.7	11.9	44.4
37	11.9	1.5	55.1	10.0	14.9	66.6	5.52	10.8	58.1	33.6	12.1	56.5
-37	44.9	5.5	100.0	5.96	33.4	100.0	5.69	41.9	100.0	32.2	43.5	100.0
Total	**100.0**	**12.3**	--	**8.00**	**100.0**	--	**6.10**	**100.0**	--	**33.2**	**100.0**	--

Unit Column Tail 708.81 kg/h 98.3% mass fraction

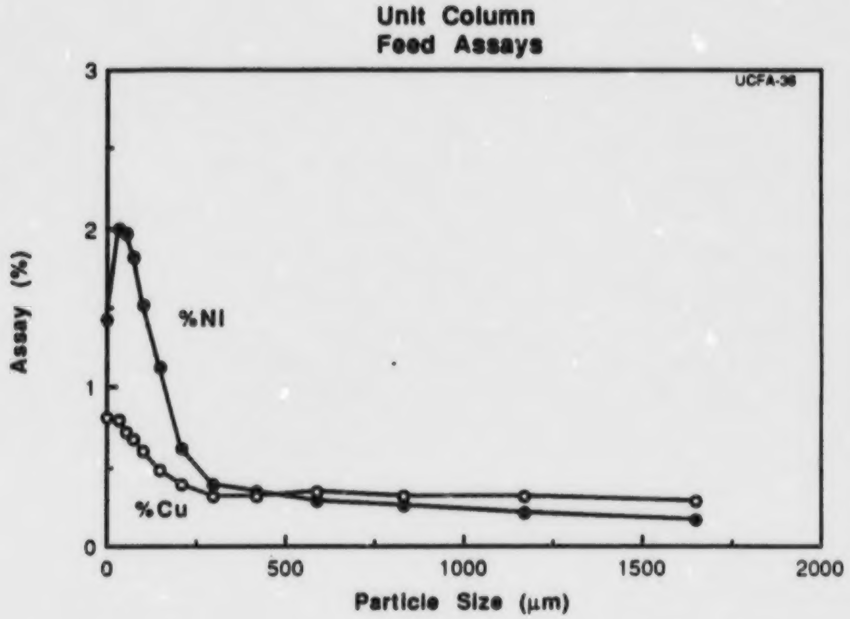
Particle	Solids			Nickel			Copper			Sulphur		
Size	% Ret.	Rate	% Ret.	Assay	Distribution		Assay	Distribution		Assay	Distribution	
µm	Indiv.	kg/h	Cuml.	%Ni	Indiv.	Cuml.	%Cu	Indiv.	Cuml.	%S	Indiv.	Cuml.
1,651	2.2	15.6	2.2	0.11	0.7	0.7	0.27	2.2	2.2	1.08	0.6	0.6
1,168	11.6	82.0	13.8	0.17	5.5	6.1	0.26	11.1	13.3	1.54	4.9	5.5
833	13.4	94.9	27.2	0.19	7.1	13.2	0.29	14.4	27.7	1.89	6.9	12.4
589	15.6	110.7	42.8	0.23	10.0	23.2	0.30	17.3	45.0	2.39	10.2	22.6
417	15.1	107.3	57.9	0.24	10.1	33.2	0.29	16.2	61.2	3.13	12.9	35.5
295	12.2	86.4	70.1	0.30	10.2	43.4	0.27	12.2	73.4	4.31	14.3	49.8
208	6.6	46.6	76.7	0.42	7.7	51.1	0.28	6.8	80.2	5.83	10.4	60.2
147	3.5	25.1	80.2	0.58	5.7	56.8	0.24	3.1	83.4	6.98	6.7	67.0
104	2.6	18.6	82.8	0.61	4.4	61.2	0.19	1.8	85.2	7.30	5.2	72.2
74	2.5	17.7	85.3	0.64	4.4	65.6	0.14	1.3	86.5	7.77	5.3	77.5
53	2.2	15.8	87.6	0.71	4.4	70.0	0.12	1.0	87.5	8.67	5.3	82.7
37	1.8	13.1	89.4	0.80	4.1	74.1	0.11	0.8	88.3	8.51	4.3	87.0
-37	10.6	75.1	100.0	0.88	25.9	100.0	0.30	11.7	100.0	4.50	13.0	100.0
Total	**100.0**	**708.8**	--	**0.36**	**100.0**	--	**0.27**	**100.0**	--	**3.67**	**100.0**	--

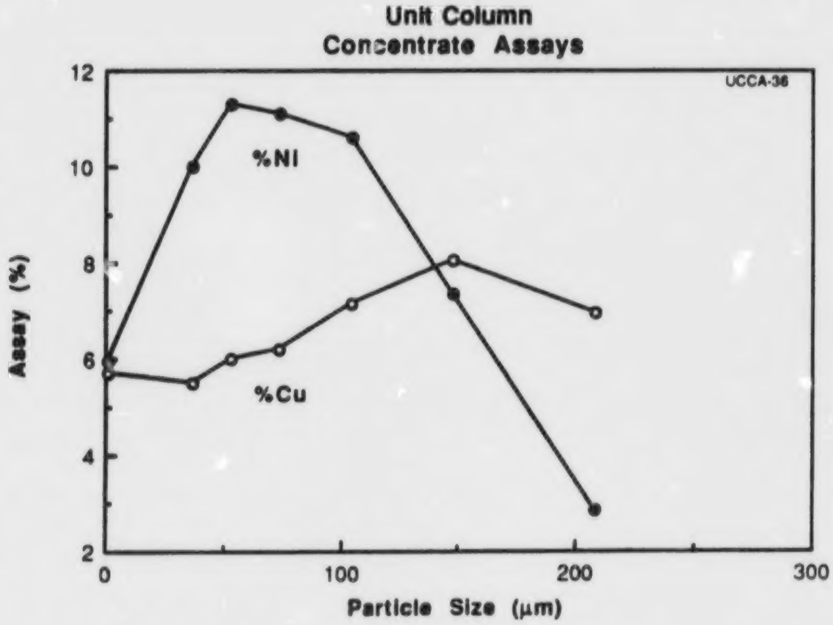
Unit Column Feed (calc) 721.1 kg/h 100% mass fraction

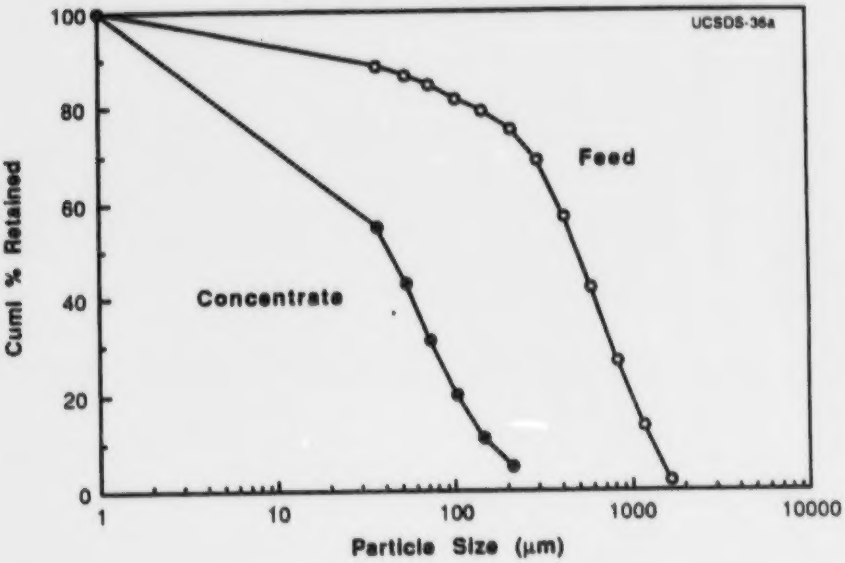
Particle	Solids			Nickel			Copper			Sulphur		
Size	% Ret.	Rate	% Ret.	Assay	Distribution		Assay	Distribution		Assay	Distribution	
µm	Direct	kg/h	Cuml.	%Ni	Indiv.	Cuml.	%Cu	Indiv.	Cuml.	%S	Indiv.	Cuml.
1,651	2.2	15.6	2.2	0.17	0.5	0.5	0.29	1.6	1.6	1.55	0.6	0.6
1,168	11.4	82.0	13.5	0.21	3.9	4.4	0.31	8.0	9.6	1.87	4.2	4.8
833	13.2	94.9	26.7	0.25	5.1	9.5	0.31	10.3	19.9	2.34	6.0	10.7
589	15.3	110.7	42.0	0.29	7.2	16.7	0.34	12.5	32.4	3.00	8.8	19.5
417	14.9	107.3	56.9	0.34	7.3	24.0	0.32	11.7	44.0	4.27	11.2	30.7
295	12.0	86.4	68.9	0.39	7.3	31.3	0.31	8.8	52.8	5.91	12.4	43.0
208	6.5	47.2	75.5	0.61	6.0	37.4	0.39	6.5	59.3	8.12	9.9	52.9
147	3.6	25.8	79.0	1.13	5.6	43.0	0.48	4.4	63.7	11.5	6.6	59.5
104	2.7	19.6	81.8	1.52	6.4	49.4	0.60	4.2	67.9	12.6	5.7	65.2
74	2.7	19.1	84.4	1.82	7.6	57.0	0.68	4.2	72.1	12.9	6.1	71.4
53	2.4	17.3	86.8	1.97	7.9	64.9	0.72	4.1	76.2	13.2	6.2	77.5
37	2.0	14.5	88.8	2.00	7.1	72.0	0.79	3.6	79.8	12.8	5.3	82.9
-37	11.2	80.6	100.0	1.43	28.0	100.0	0.81	20.2	100.0	8.61	17.1	100.0
Total	**100.0**	**721.1**	--	**0.49**	**100.0**	--	**0.37**	**100.0**	--	**4.17**	**100.0**	--

Recovery to Column Concentrate

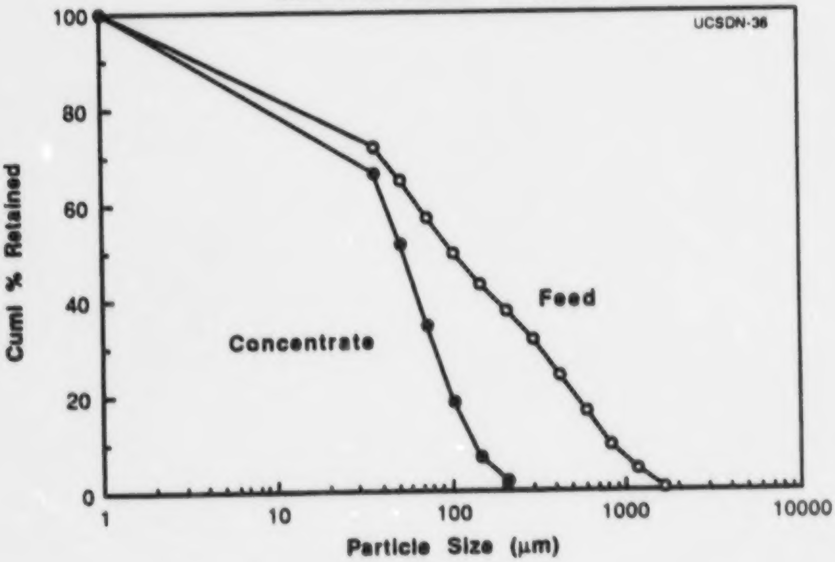
Size	Recovery to Concentrate			
	Solids	Ni	Cu	S
µm	Indiv.	Indiv.	Indiv.	Indiv.
208	1.3	8.3	24.9	8.6
147	2.8	26.6	48.9	12.1
104	5.4	50.0	68.5	20.8
74	7.4	58.0	77.9	25.6
53	8.6	60.0	82.5	26.2
37	10.1	58.4	84.9	30.7
-37	6.9	33.3	58.3	34.5


Unit Column
Feed Assays
UCFA-36
%Ni
%Cu
Assay (%)
0
1
2
3
0
500
1000
1500
2000
Particle Size (μm)


Unit Column
Concentrate Assays
UCCA-36
%Ni
%Cu
Assay (%)
2
4
6
8
10
12
0
100
200
300
Particle Size (μm)

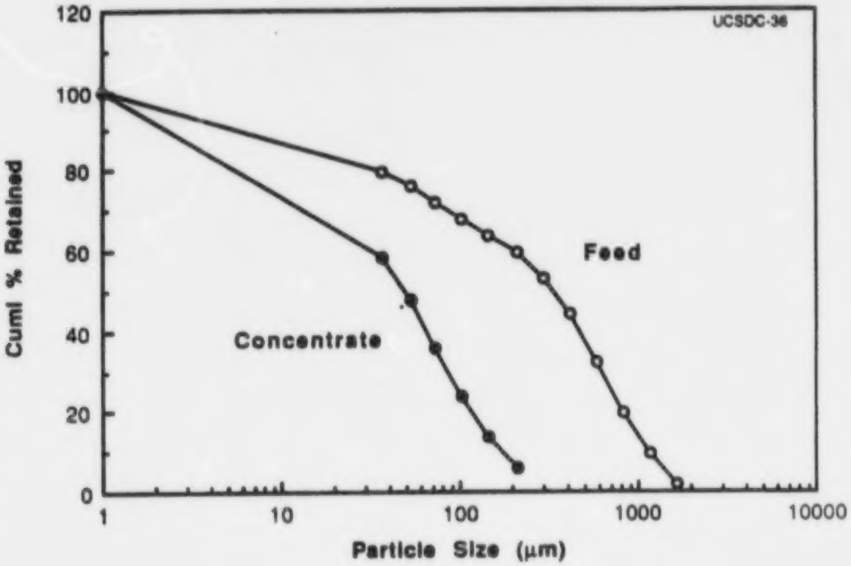


Unit Column
Size Distribution of Solids

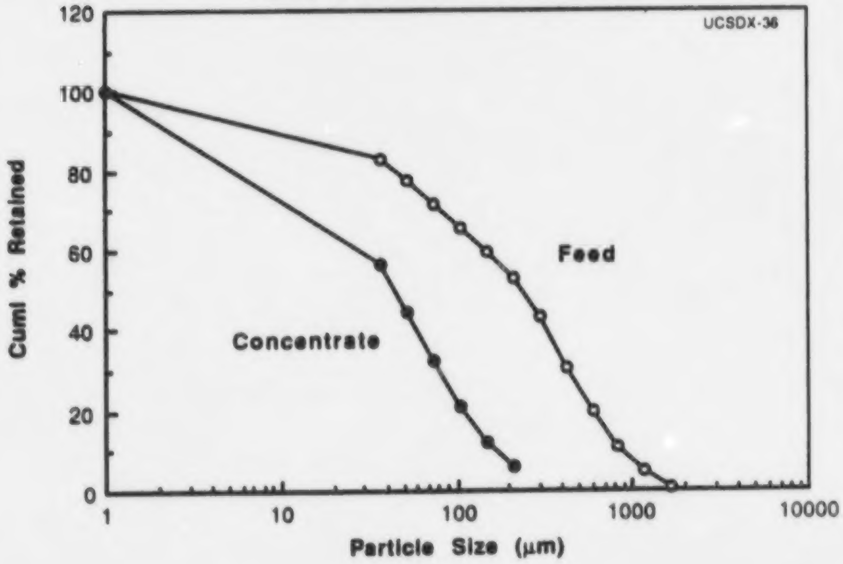


Unit Column
Size Distribution of Nickel

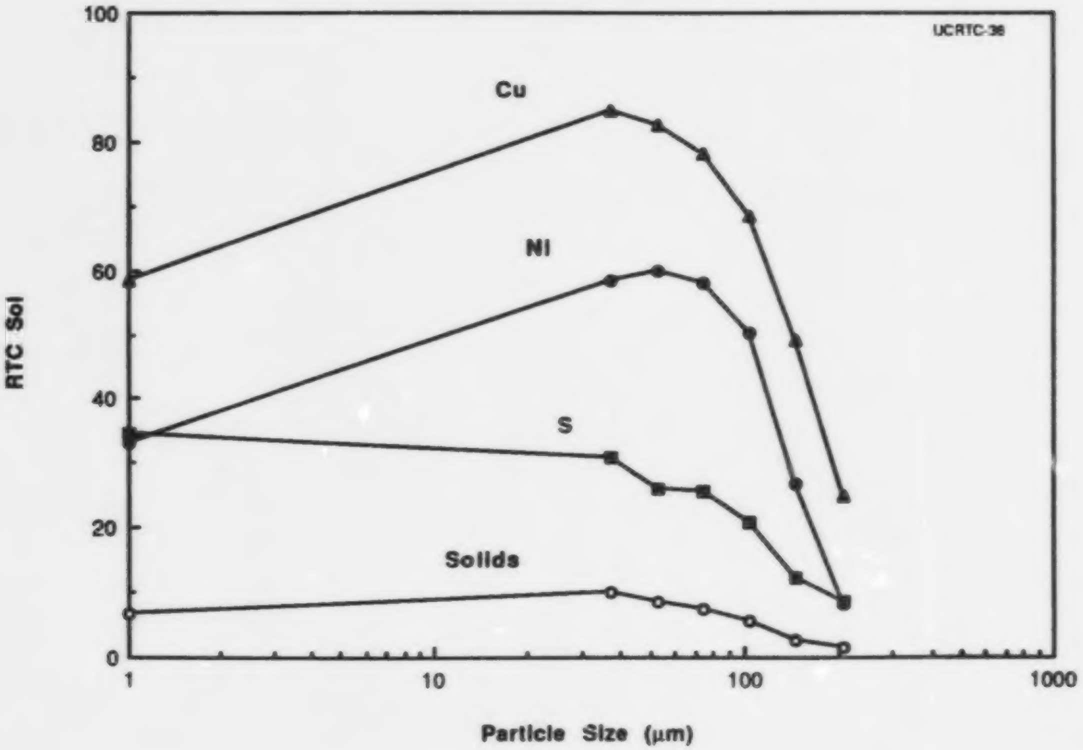
Unit Column
Size Distribution of Copper



Unit Column
Size Distribution of Sulphur



Unit Column
Recovery to Concentrate



Primary Rougher Feed 178.80 kg/h 100% mass fraction

Particle	Solids			Nickel			Copper			Sulphur		
Size	% Ret.	Rate	% Ret.	Assay	Distribution		Assay	Distribution		Assay	Distribution	
µm	Indiv.	kg/h	Cuml.	%Ni	Indiv.	Cuml.	%Cu	Indiv.	Cuml.	%S	Indiv.	Cuml.
208	13.8	24.7	13.8	0.78	12.4	12.4	0.35	21.4	21.4	9.2	13.9	13.9
147	16.7	29.9	30.5	0.82	15.8	28.3	0.29	21.5	42.9	10.2	18.8	32.7
104	13.4	23.9	43.9	0.93	14.4	42.6	0.18	10.7	53.5	10.4	15.3	48.1
74	11.4	20.4	55.3	0.86	11.4	54.0	0.14	7.1	60.6	10.6	13.4	61.5
53	9.0	16.1	64.3	0.90	9.3	63.3	0.11	4.4	65.0	10.9	10.8	72.3
37	6.8	12.1	71.1	0.93	7.3	70.6	0.10	3.0	68.0	10.3	7.7	80.0
-37	28.9	51.7	100.0	0.88	29.4	100.0	0.25	32.0	100.0	6.3	20.0	100.0
Total	**100.0**	**178.8**	--	**0.87**	**100.0**	--	**0.23**	**100.0**	--	**9.1**	**100.0**	--

Prim. Rghr. Concentrate 15.35 kg/h 8.58% mass fraction

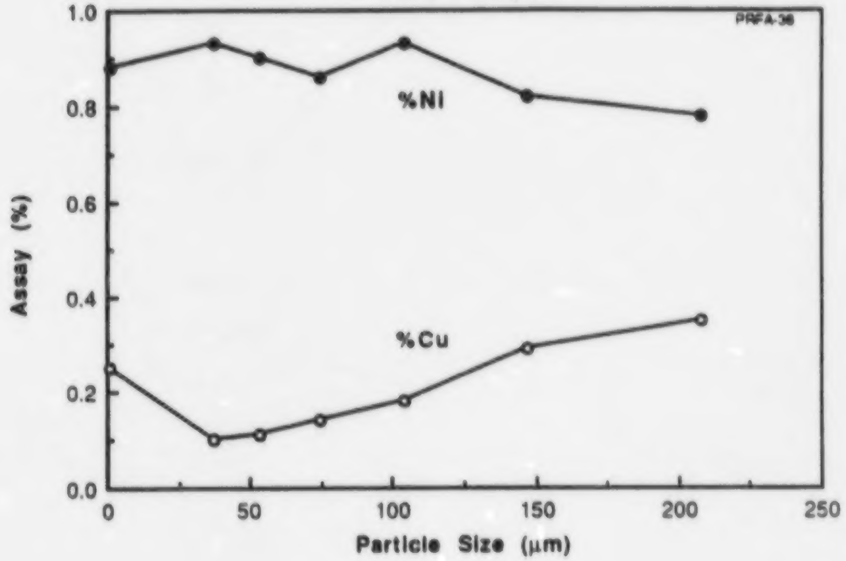
Particle	Solids			Nickel			Copper			Sulphur		
Size	% Ret.	Rate	% Ret.	Assay	Distribution		Assay	Distribution		Assay	Distribution	
µm	Indiv.	kg/h	Cuml.	%Ni	Indiv.	Cuml.	%Cu	Indiv.	Cuml.	%S	Indiv.	Cuml.
208	8.6	1.3	8.6	3.20	6.1	6.1	3.75	17.6	17.6	21.9	7.0	7.0
147	15.3	2.3	23.9	4.26	14.5	20.6	2.50	20.8	38.3	26.0	14.6	21.6
104	10.4	1.6	34.3	6.34	14.7	35.3	2.24	12.7	51.0	28.0	10.8	32.3
74	7.9	1.2	42.2	6.83	12.0	47.3	1.72	7.4	58.4	28.4	8.2	40.6
53	7.9	1.2	50.2	6.36	11.2	58.5	1.20	5.2	63.6	32.6	9.5	50.1
37	7.2	1.1	57.4	4.81	7.7	66.2	0.77	3.0	66.6	34.0	9.0	59.2
-37	42.6	6.5	100.0	3.56	33.8	100.0	1.44	33.4	100.0	26.0	40.8	100.0
Total	**100.0**	**15.3**	--	**4.50**	**100.0**	--	**1.84**	**100.0**	--	**27.14**	**100.0**	--

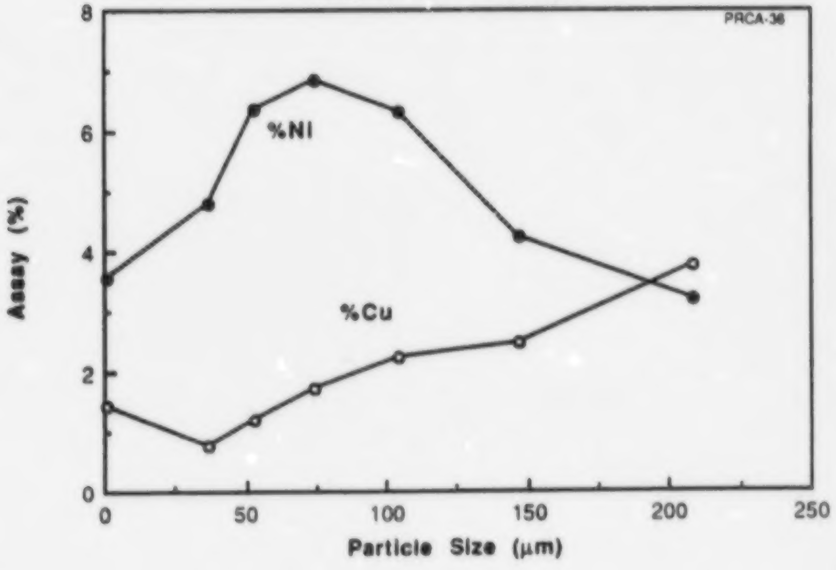
Prim. Rghr. Tail (calc) 163.45 kg/h 91% mass fraction

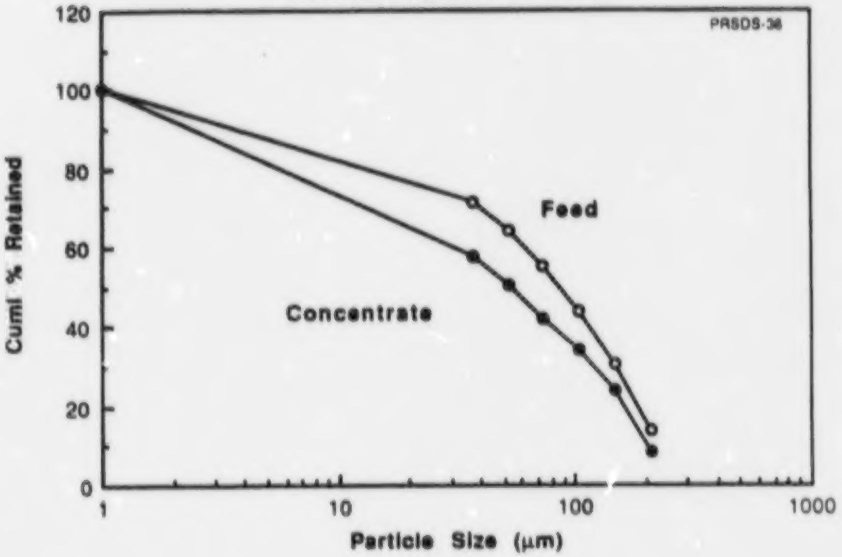
Particle	Solids			Nickel			Copper			Sulphur		
Size	% Ret.	Rate	% Ret.	Assay	Distribution		Assay	Distribution		Assay	Distribution	
µm	Direct	kg/h	Cuml.	%Ni	Indiv.	Cuml.	%Cu	Indiv.	Cuml.	%S	Indiv.	Cuml.
208	14.3	23.4	14.3	0.61	10.5	10.5	0.39	19.8	19.8	8.12	12.5	12.5
147	16.9	27.6	31.1	1.13	15.4	25.9	0.48	21.2	41.0	11.5	18.0	30.5
104	13.6	22.3	44.8	1.52	14.5	40.4	0.60	11.5	52.5	12.6	14.4	44.9
74	11.8	19.2	56.6	1.82	11.5	51.9	0.68	7.2	59.7	12.9	12.3	57.2
53	9.1	14.8	65.6	1.97	9.9	61.9	0.72	4.7	64.4	13.2	10.5	67.7
37	6.8	11.0	72.4	2.00	7.4	69.3	0.79	3.0	67.4	12.8	8.0	75.7
-37	27.6	45.1	100.0	1.43	30.7	100.0	0.81	32.6	100.0	8.61	24.3	100.0
Total	**100.0**	**163.5**	--	**1.37**	**100.0**	--	**0.42**	**100.0**	--	**12.46**	**100.0**	--

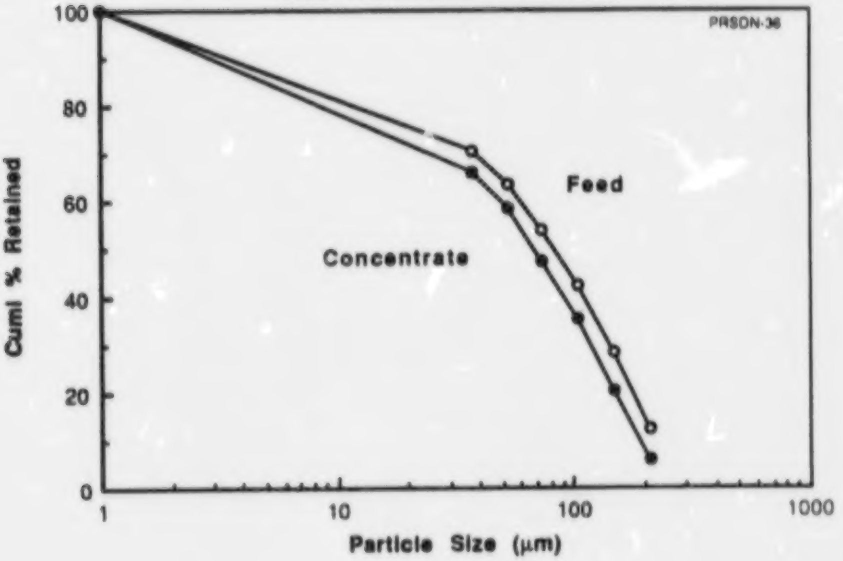
Recovery to Prim Rghr Concentrate

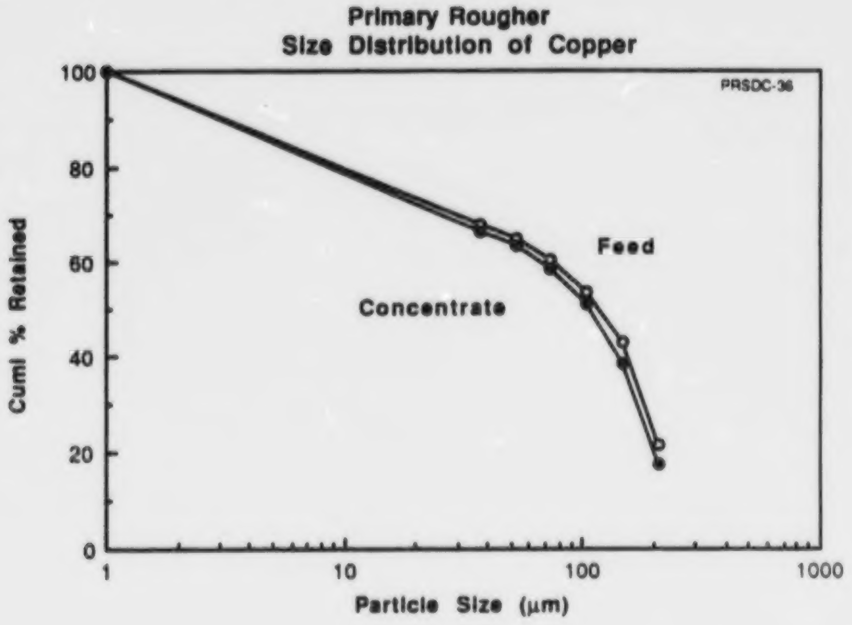
Size	Recovery to Concentrate			
	Solids	Ni	Cu	S
µm	Indiv.	Indiv.	Indiv.	Indiv.
208	5.4	22.0	57.5	12.8
147	7.8	40.7	67.6	20.0
104	6.7	45.6	83.3	18.0
74	5.9	47.0	72.7	15.9
53	7.6	53.6	82.8	22.7
37	9.1	47.1	70.1	30.0
-37	12.7	51.3	73.0	52.5

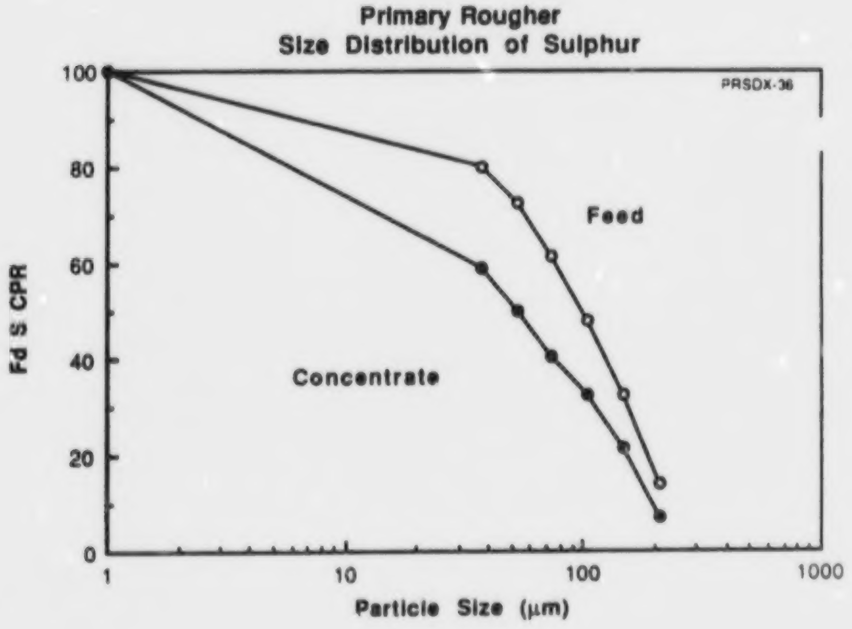

Primary Rougher
Feed Assays

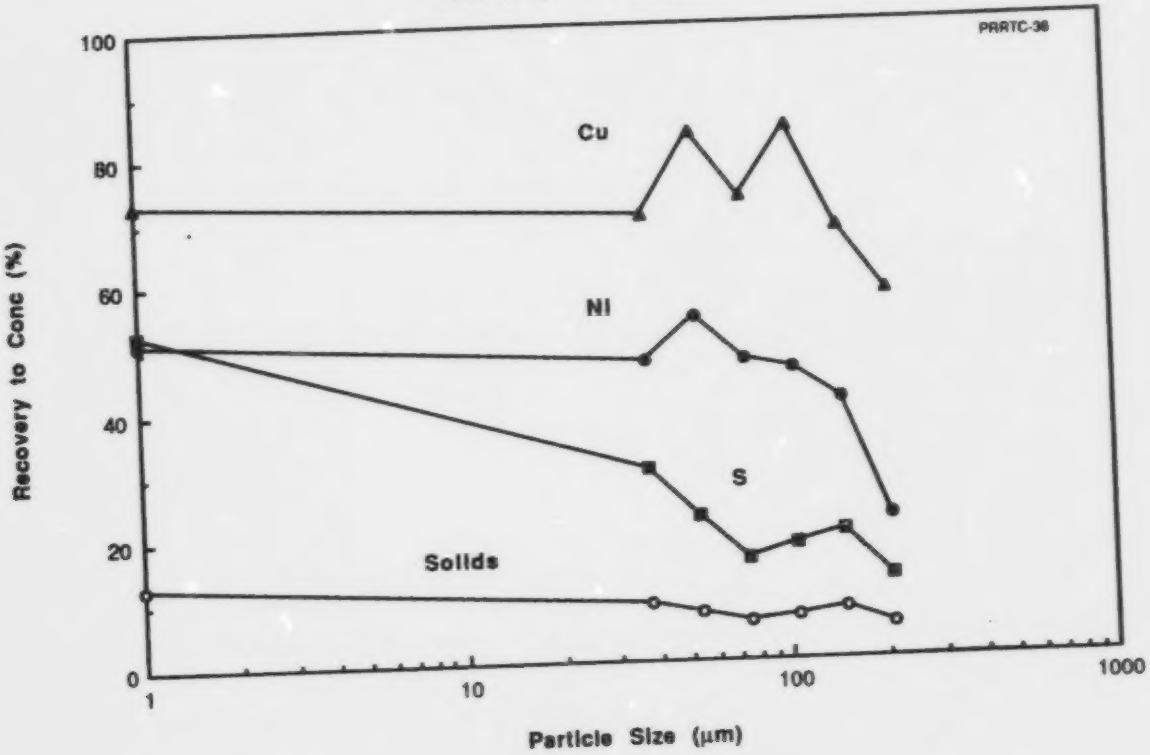

Primary Rougher
Concentrate Assays


Primary Rougher
Size Distribution of Solids


Primary Rougher
Size Distribution of Nickel


Primary Rougher
Size Distribution of Copper


Primary Rougher
Size Distribution of Sulphur



Primary Rougher
Recovery to Concentrate

1. **Purpose:** To conduct a comparison test without the Unit Column.

2. **Procedure:** All process units started with the exception of the unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		87.2 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.24	0.63	3.03	1.83	6.15
Unit Column	Grade	--	--	--	--	--
	Recov	--	--	--	--	--
Primary Rougher	Grade	5.83	3.86	14.93	11.18	3.03
	Recov	67.1	87.4	70.3	87.4	5.36
Secondary Rougher	Grade	3.33	1.30	8.29	3.76	5.38
	Recov	1.2	0.9	1.2	0.9	0.25
Scavenger	Grade	1.65	0.21	3.45	0.60	17.7
	Recov	24.3	6.0	20.8	6.0	8.33
Overall Circuit	Grade	3.49	1.80	8.51	5.22	6.36
	Recov	92.9	94.1	92.6	94.1	13.85

Chemical size analyses were conducted, as in test PP-36.

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	199.1 kg/h of -1/4 inch feed. (Wet Sple 995.8 g)
	(Dry Sple 985.3 g)
Feed Rate:	197.0 kg/h of dry ore. (Moisture 1.05 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 995 kg in 5.00 hr
	Sample 398 kg in 2.00 hr
Rod Mill Discharge:	1,680 g/L (57 % Sol at Solid SG of 3.39)
	47.9 % plus 48 mesh
	38.2 % minus 100 mesh
Input Power:	33.82 for 3 disc revolutions
	1.15 kW (95% drive efficiency)
Average Power:	1.09 kW Gross
	0.47 kW No Load
	0.62 kW Net
Net Power Usage:	3.14 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,486 microns
K80 Product:	802 microns
Work Index (metric):	15.4

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 493 % circ. load)
Feed Rate:	970.8 kg/h
Mill Speed:	41 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,163 g/L (20 % Sol at S 3.39)
Ball Mill Discharge:	1,740 g/L (60 % Sol at S 3.39)
	79.1 % plus 48 mesh
	6.7 % minus 100 mesh
Input Power:	25.89 for 3 disc revolutions
	1.50 kW (95% drive efficiency)
Average Power:	1.43 kW Gross
	0.52 kW No Load
	0.90 kW Net
Net Power Usage:	0.93 kWh/tonne of screen oversize.
K80 Feed:	802 microns
K80 Product:	110 microns
Work Index (metric):	1.6

3.1.3. Overall Mill Report:

Net Power Usage:	4.07 kWh/t
K80 Feed:	4,486 microns
K80 Product:	110 microns
Work Index (metric):	5.1
Screen Undersize:	87.2 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,486	17.8
Rod Mill Discharge	802	38.2
Ball Mill Feed	966	3.4
Ball Mill Discharge	898	6.7
Column Feed	--	--
Column Conc	--	--
Screen Feed	881	15.0
Screen Undersize	110	87.2
Prim Rghr Conc	124	84.6
Sec Rghr Conc	53	95.1
Scavenger Tail	168	74.2

3.2. Reagent Additions:

Average Feed Rate: 0.197 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Rougher Feed	NaIX	2.0%	8.4	51.2
	DF-250	2.0%	7.8	47.5
Scavenger 1 Feed	NaIX	2.0%	7.0	42.6
	DF-250	2.0%	2.0	12.2
	CuSO4	2.0%	6.2	37.8
Scavenger 2 Feed	NaIX	2.0%	5.0	30.5
	DF-250	2.0%	4.1	25.0
Total	**NaIX**		20.4	**124.3**
	DF-250		13.9	**84.7**
	CuSO4		6.2	**37.8**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,680			3.27
Ball Mill Discharge	1,740			
Screen Feed	1,633	9.56		
Screen Undersize	1,163	9.25	24.8	
Scavenger 1 Feed	1,158	8.65		
Scavenger 2 Tail	1,214			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	--	--	--	--
Primary Rougher	56	197	1.63	3.6	15.6
Secondary Rougher	28	169	1.16	12.4	2.3
Scavenger	336	168	1.21	9.1	37.0
Total	420				54.8

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 484%** **From BILCO 493%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.17	0.60	9.26	1.24	0.63	9.08	197.0	100.00
Rod Mill Discharge	1.10	0.61	8.2	1.24	0.63	9.08	197.0	100.00
Ball Mill Feed	0.44	0.31	4.65	0.43	0.32	4.84	970.8	492.85
Ball Mill Discharge	0.42	0.32	4.91	0.43	0.32	4.84	970.8	492.85
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Screen Feed	0.58	0.40	5.68	0.57	0.37	5.56	1,167.8	592.85
Screen Undersize	1.51	0.89	8.8	1.24	0.63	9.08	197.0	100.00
Prim Rghr Conc	6.33	3.60	28.2	5.83	3.86	26.9	28.1	14.28
Prim Rghr Tail	0.49	0.09	6.22	0.47	0.09	6.10	168.9	85.72
Sec Rghr Conc	3.33	1.30	21.8	3.33	1.30	21.8	0.9	0.44
Sec Rghr Tail	0.48	0.082	6.60	0.46	0.088	6.02	168.0	85.29
Scavenger Conc	1.59	0.220	24.8	1.65	0.207	25.7	36.0	18.27
Scavenger Tail	0.13	0.059	0.64	0.13	0.055	0.64	132.0	67.02

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

	Overall	Metal Assays			Mineral Assays			Ratio
Product	Wt %	% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.24	0.63	9.1	3.03	18.6	1.83	6.1
Combined Conc	33.0	3.49	1.80	26.2	8.51	54.1	5.22	6.4
Final Tail	67.0	0.13	0.06	0.64	0.34	1.2	0.16	3.5
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	1.24	0.63	9.08	3.03	18.6	1.83	6.1
Prim Rghr Conc	14.3	5.83	3.86	26.9	14.93	45.2	11.18	3.0
Prim Rghr Tail	85.7	0.47	0.09	6.10	1.04	14.2	0.27	13.7
Sec Rghr Feed	85.7	0.47	0.09	6.10	1.04	14.2	0.27	13.7
Sec Rghr Conc	0.4	3.33	1.30	21.8	8.29	44.6	3.76	5.4
Sec Rghr Tail	85.3	0.46	0.09	6.02	1.00	14.0	0.26	14.0
Comb Rghr Feed	100.0	1.24	0.63	9.08	3.03	18.6	1.83	6.1
Comb Rghr Conc	14.7	5.75	3.78	26.8	14.73	45.2	10.96	3.1
Comb Rghr Tail	85.3	0.46	0.09	6.02	1.00	14.0	0.26	14.0
Scavenger Feed	85.3	0.46	0.09	6.02	1.00	14.0	0.26	14.0
Scavenger Conc	18.3	1.65	0.21	25.7	3.45	61.1	0.60	17.7
Scavenger Tail	67.0	0.13	0.06	0.64	0.34	1.2	0.16	3.5
Comb Mech Feed	100.0	1.24	0.63	9.08	3.03	18.6	1.83	6.1
Comb Mech Conc	33.0	3.49	1.80	26.2	8.51	54.1	5.22	6.4
Comb Mech Tail	67.0	0.13	0.06	0.64	0.34	1.2	0.16	3.5
Col + P.Rghr Feed	100.0	1.24	0.63	9.1	3.03	18.6	1.83	6.1
Col + P.Rghr Conc	14.3	5.85	3.85	27.0	15.0	45.3	11.2	3.0
Col + P.Rghr Tail	85.7	0.47	0.09	6.1	1.04	14.2	0.27	13.7

4.3. Metallurgical Balance - Distributions:

Product	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	33.0	92.9	94.1	95.3	92.6	95.7	94.1	13.9
Final Tail	67.0	7.1	5.9	4.7	7.4	4.3	5.9	86.1
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	14.3	67.1	87.4	42.4	70.3	34.6	87.4	5.4
Prim Rghr Tail	85.7	32.9	12.6	57.6	29.7	65.4	12.6	94.6
Sec Rghr Feed	85.7	32.6	12.8	57.5	29.4	65.3	12.8	94.7
Sec Rghr Conc	0.4	1.2	0.9	1.0	1.2	1.0	0.9	0.2
Sec Rghr Tail	85.3	31.4	11.9	56.5	28.2	64.3	11.9	94.4
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	14.7	68.3	88.3	43.4	71.5	35.6	88.3	5.6
Comb Rghr Tail	85.3	31.7	11.7	56.6	28.5	64.4	11.7	94.4
Scavenger Feed	85.3	31.4	11.9	56.5	28.2	64.3	11.9	94.4
Scavenger Conc	18.3	24.3	6.0	51.6	20.8	59.8	6.0	8.3
Scavenger Tail	67.0	7.1	5.9	4.9	7.4	4.4	5.9	86.1
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	33.0	92.9	94.1	95.3	92.6	95.7	94.1	13.9
Comb Mech Tail	67.0	7.1	5.9	4.7	7.4	4.3	5.9	86.1
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.3	67.4	87.2	42.5	70.6	34.7	87.2	5.3
Col + P.Rghr Tail	85.7	32.6	12.8	57.5	29.4	65.3	12.8	94.7

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	33.0	92.9	94.1	95.3	92.6	95.7	94.1	13.9
Final Tail	67.0	7.1	5.9	4.7	7.4	4.3	5.9	86.1
Unit Column Feed	--	--	--	--	--	--	--	--
Unit Column Conc	--	--	--	--	--	--	--	--
Unit Column Tail	--	--	--	--	--	--	--	--
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	14.3	67.1	87.4	42.4	70.3	34.6	87.4	5.4
Prim Rghr Tail	85.7	32.9	12.6	57.6	29.7	65.4	12.6	94.6
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	0.5	3.6	7.0	1.8	4.0	1.6	7.0	0.3
Sec Rghr Tail	99.5	96.4	93.0	98.2	96.0	98.4	93.0	99.7
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	14.7	68.3	88.3	43.4	71.5	35.6	88.3	5.6
Comb Rghr Tail	85.3	31.7	11.7	56.6	28.5	64.4	11.7	94.4
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	21.4	77.4	50.4	91.4	73.7	93.1	50.4	8.8
Scavenger Tail	78.6	22.6	49.6	8.6	26.3	6.9	49.6	91.2
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	33.0	92.9	94.1	95.3	92.6	95.7	94.1	13.9
Comb Mech Tail	67.0	7.1	5.9	4.7	7.4	4.3	5.9	86.1
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.3	67.4	87.2	42.5	70.6	34.7	87.2	5.3
Col + P.Rghr Tail	85.7	32.6	12.8	57.5	29.4	65.3	12.8	94.7

5. Screen Analyses:

Detailed in the following pages.

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	145.0	16.8	16.8	83.2
6	3,327	152.1	17.6	34.5	65.5
8	2,362	88.5	10.3	44.7	55.3
10	1,651	87.5	10.1	54.9	45.1
14	1,168	53.0	6.1	61.0	39.0
20	833	40.4	4.7	65.7	34.3
28	589	34.4	4.0	69.7	30.3
35	417	30.3	3.5	73.2	26.8
48	295	26.3	3.0	76.2	23.8
65	208	25.8	3.0	79.2	20.8
100	147	25.8	3.0	82.2	17.8
150	104	22.8	2.6	84.9	15.1
200	74	22.1	2.6	87.4	12.6
270	53	20.5	2.4	89.8	10.2
400	37	16.0	1.9	91.7	8.3
Pan	-37	71.9	8.3	100.0	-
Total	-	**862.4**	**100.0**	-	-
K80	**4,486**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	13.9	2.7	2.7	97.3
14	1,168	32.0	6.2	8.9	91.1
20	833	50.0	9.7	18.7	81.3
28	589	58.2	11.3	30.0	70.0
35	417	51.8	10.1	40.1	59.9
48	295	40.1	7.8	47.9	52.1
65	208	36.2	7.1	55.0	45.0
100	147	35.0	6.8	61.8	38.2
150	104	30.2	5.9	67.7	32.3
200	74	28.2	5.5	73.2	26.8
270	53	24.6	4.8	78.0	22.0
400	37	20.1	3.9	81.9	18.1
Pan	-37	93.0	18.1	100.0	-
Total	-	**513.3**	**100.0**	-	-
K80	**802**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	26.7	3.8	3.8	96.2
14	1,168	58.1	8.3	12.2	87.8
20	833	96.2	13.8	26.0	74.0
28	589	137.3	19.7	45.7	54.3
35	417	149.7	21.5	67.1	32.9
48	295	124.4	17.8	85.0	15.0
65	208	63.1	9.1	94.0	6.0
100	147	18.2	2.6	96.6	3.4
150	104	6.7	1.0	97.6	2.4
200	74	3.4	0.5	98.1	1.9
270	53	2.2	0.3	98.4	1.6
400	37	1.4	0.2	98.6	1.4
Pan	-37	9.7	1.4	100.0	-
Total	-	**697.1**	**100.0**	-	-
K80	**966**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	10.0	2.8	2.8	97.2
14	1,168	25.9	7.2	9.9	90.1
20	833	45.1	12.5	22.4	77.6
28	589	65.3	18.1	40.5	59.5
35	417	73.2	20.2	60.7	39.3
48	295	66.3	18.3	79.1	20.9
65	208	37.9	10.5	89.5	10.5
100	147	13.6	3.8	93.3	6.7
150	104	6.0	1.7	95.0	5.0
200	74	3.7	1.0	96.0	4.0
270	53	2.6	0.7	96.7	3.3
400	37	1.8	0.5	97.2	2.8
Pan	-37	10.1	2.8	100.0	-
Total	-	**361.5**	**100.0**	-	-
K80	**898**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	11.6	2.7	2.7	97.3
14	1,168	28.8	6.8	9.5	90.5
20	833	51.5	12.1	21.6	78.4
28	589	70.3	16.5	38.2	61.8
35	417	75.2	17.7	55.9	44.1
48	295	66.3	15.6	71.5	28.5
65	208	38.3	9.0	80.5	19.5
100	147	19.1	4.5	85.0	15.0
150	104	12.1	2.8	87.9	12.1
200	74	9.5	2.2	90.1	9.9
270	53	7.4	1.7	91.8	8.2
400	37	8.2	1.9	93.8	6.2
Pan	-37	26.5	6.2	100.0	-
Total	-	424.8	100.0	-	-
K80	881				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	11.6	5.4	5.4	94.6
100	147	16.2	7.5	12.8	87.2
150	104	18.0	8.3	21.2	78.8
200	74	21.5	9.9	31.1	68.9
270	53	23.4	10.8	41.9	58.1
400	37	19.3	8.9	50.8	49.2
Pan	-37	106.5	49.2	100.0	-
Total	-	216.5	100.0	-	-
K80	110				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	11.3	5.1	5.1	94.9
100	147	23.0	10.3	15.4	84.6
150	104	21.7	9.7	25.1	74.9
200	74	22.4	10.1	35.2	64.8
270	53	24.6	11.0	46.3	53.7
400	37	21.0	9.4	55.7	44.3
Pan	-37	98.7	44.3	100.0	-
Total	-	**222.7**	**100.0**	-	-
K80	**124**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.0	2.6	2.6	97.4
100	147	1.8	2.3	4.9	95.1
150	104	1.7	2.2	7.1	92.9
200	74	3.9	5.0	12.1	87.9
270	53	6.2	8.0	20.1	79.9
400	37	6.0	7.7	27.8	72.2
Pan	-37	56.2	72.2	100.0	-
Total	-	**77.8**	**100.0**	-	-
K80	**53**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	24.0	9.7	9.7	90.3
100	147	39.9	16.1	25.8	74.2
150	104	31.8	12.9	38.7	61.3
200	74	27.1	11.0	49.7	50.3
270	53	23.7	9.6	59.2	40.8
400	37	18.0	7.3	66.5	33.5
Pan	-37	82.8	33.5	100.0	-
Total	-	**247.3**	**100.0**	-	-
K80	**168**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 μm aperture)

C L R
655%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	47.9	79.1	85.0	0.0
-48+100	13.9	14.2	11.7	12.8
-100+200	11.4	2.7	1.4	18.2
-200+400	8.7	1.2	0.5	19.7
-400	18.1	2.8	1.4	49.2

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	809 %	75.6	612 %
-48+100	-40 %	13.6	-5 %
-100+200	556 %	4.0	22 %
-200+400	1572 %	1.7	26 %
-400	2215 %	5.1	112 %
Total		100.0	655 %

Rod Mill Feed

Particle	Solids			Nickel			Copper			Sulphur		
Size	Weight	% Ret.	% Ret	Assay %Ni		% Ret	Assay %Cu		% Ret	Assay %S		% Ret
µm	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
4,699	145.0	16.8	16.8	0.43	0.43	6.6	0.45	0.45	12.1	3.74	3.74	7.6
3,327	152.1	17.6	34.5	0.59	0.51	16.1	0.55	0.50	27.7	5.18	4.48	18.6
2,362	88.5	10.3	44.7	0.70	0.56	22.7	0.41	0.48	34.5	6.08	4.85	26.1
1,651	87.5	10.1	54.9	0.70	0.58	29.1	0.51	0.49	42.8	6.21	5.10	33.7
1,168	53.0	6.1	61.0	0.77	0.60	33.5	0.46	0.48	47.3	7.50	5.34	39.3
833	40.4	4.7	65.7	0.8	0.62	37.0	0.54	0.49	51.4	8.50	5.56	44.1
589	34.4	4.0	69.7	0.96	0.64	40.5	0.56	0.49	55.0	11.1	5.88	49.5
417	30.3	3.5	73.2	1.05	0.66	43.9	0.62	0.50	58.5	13.1	6.23	55.0
295	26.3	3.0	76.2	1.15	0.68	47.1	0.63	0.50	61.5	14.3	6.55	60.3
208	25.8	3.0	79.2	1.52	0.71	51.2	0.73	0.51	65.0	15.3	6.88	65.8
147	25.8	3.0	82.2	2.20	0.76	57.2	0.81	0.52	68.9	15.7	7.20	71.5
104	22.8	2.6	84.9	2.77	0.83	63.9	0.98	0.54	73.1	16.4	7.49	76.7
74	22.1	2.6	87.4	3.09	0.89	71.1	1.03	0.55	77.3	16.2	7.74	81.7
53	20.5	2.4	89.8	3.28	0.95	78.3	1.07	0.56	81.4	16.1	7.97	86.3
37	16.0	1.9	91.7	3.08	1.00	83.5	1.12	0.58	84.7	16.1	8.13	89.9
-37	71.9	8.3	100.0	2.17	1.10	100.0	1.14	0.62	100.0	10.0	8.29	100.0
Total	**862.4**	**100.0**	--	**1.10**	--	--	**0.62**	--	--	**8.29**	--	--
Direct				**1.17**			**0.60**			**9.26**		

Rod Mill Discharge

Particle	Solids			Nickel			Copper			Sulphur		
Size	Weight	% Ret.	% Ret	Assay %Ni		% Ret	Assay %Cu		% Ret	Assay %S		% Ret
µm	grams	Indiv.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.	Indiv.	Cuml.	Cuml.
1,651	13.9	2.7	2.7	0.21	0.21	0.5	0.25	0.25	1.1	1.83	1.83	0.6
1,168	32.0	6.2	8.9	0.29	0.27	2.1	0.35	0.32	4.6	2.55	2.33	2.5
833	50.0	9.7	18.7	0.38	0.33	5.5	0.38	0.35	10.6	3.75	3.07	6.9
589	58.2	11.3	30.0	0.49	0.39	10.5	0.42	0.38	18.2	5.42	3.96	14.2
417	51.8	10.1	40.1	0.61	0.44	16.0	0.43	0.39	25.2	7.38	4.82	23.1
295	40.1	7.8	47.9	0.72	0.49	21.0	0.47	0.40	31.1	9.11	5.52	31.6
208	36.2	7.1	55.0	0.98	0.55	27.2	0.55	0.42	37.4	11.3	6.26	41.2
147	35.0	6.8	61.8	1.28	0.63	35.1	0.61	0.44	44.1	11.5	6.84	50.5
104	30.2	5.9	67.7	1.93	0.74	45.3	0.78	0.47	51.5	12.8	7.36	59.5
74	28.2	5.5	73.2	1.94	0.83	54.9	0.77	0.49	58.3	12.5	7.74	67.8
53	24.6	4.8	78.0	2.16	0.92	64.2	0.87	0.52	65.0	12.5	8.04	74.9
37	20.1	3.9	81.9	2.36	0.99	72.5	0.97	0.54	71.1	13.5	8.30	81.2
-37	93.0	18.1	100.0	1.69	1.11	100.0	0.99	0.62	100.0	8.65	8.36	100.0
Total	**513.3**	**100.0**	--	**1.11**	--	--	**0.62**	--	--	**8.36**	--	--
Direct				**1.10**			**0.61**			**8.20**		

Ball Mill Feed

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni Indiv.	Assay %Ni Cuml.	% Ret Cuml.	Assay %Cu Indiv.	Assay %Cu Cuml.	% Ret Cuml.	Assay %S Indiv.	Assay %S Cuml.	% Ret Cuml.
1,651	26.7	3.8	3.8	0.19	0.19	1.8	0.27	0.27	3.1	1.64	1.64	1.3
1,168	58.1	8.3	12.2	0.20	0.20	6.0	0.27	0.27	9.8	1.93	1.84	4.8
833	96.2	13.8	26.0	0.23	0.21	14.1	0.31	0.29	22.5	2.49	2.18	12.1
589	137.3	19.7	45.7	0.28	0.24	28.0	0.30	0.30	40.2	3.17	2.61	25.4
417	149.7	21.5	67.1	0.34	0.27	46.4	0.31	0.30	60.0	4.57	3.24	46.4
295	124.4	17.8	85.0	0.42	0.30	65.4	0.35	0.31	78.6	6.06	3.83	69.5
208	63.1	9.1	94.0	0.56	0.33	78.2	0.39	0.32	89.1	8.42	4.27	85.8
147	18.2	2.6	96.6	1.06	0.35	85.2	0.51	0.32	93.1	11.4	4.46	92.1
-147	23.4	3.4	100.0	1.75	0.40	100.0	0.69	0.34	100.0	11.0	4.68	100.0
Total	**697.1**	**100.0**	--	**0.40**	--	--	**0.34**	--	--	**4.68**	--	--
Direct				**0.44**			**0.31**			**4.65**		

Ball Mill Discharge

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni Indiv.	Assay %Ni Cuml.	% Ret Cuml.	Assay %Cu Indiv.	Assay %Cu Cuml.	% Ret Cuml.	Assay %S Indiv.	Assay %S Cuml.	% Ret Cuml.
1,651	0.0	0.0	0.0	0.00	--	0.0	0.00	--	0.0	0.00	--	0.0
1,168	35.9	9.9	9.9	0.19	0.19	4.7	0.28	0.28	8.3	1.70	1.70	3.6
833	45.1	12.5	22.4	0.20	0.20	11.0	0.29	0.29	19.0	2.18	1.97	9.4
589	65.3	18.1	40.5	0.24	0.22	21.9	0.31	0.30	35.7	3.02	2.44	20.9
417	73.2	20.2	60.7	0.30	0.24	37.1	0.30	0.30	53.8	4.21	3.03	39.0
295	66.3	18.3	79.1	0.39	0.28	55.1	0.31	0.30	70.7	6.31	3.79	63.6
208	37.9	10.5	89.5	0.44	0.30	66.6	0.32	0.30	80.7	6.62	4.12	78.4
147	13.6	3.8	93.3	0.97	0.32	75.8	0.46	0.31	85.9	11.6	4.42	87.6
-147	24.2	6.7	100.0	1.44	0.40	100.0	0.71	0.34	100.0	8.70	4.71	100.0
Total	**361.5**	**100.0**	--	**0.40**	--	--	**0.34**	--	--	**4.71**	--	--
Direct				**0.42**			**0.32**			**4.91**		

Screen Feed

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni		% Ret Cuml.	Assay %Cu		% Ret Cuml.	Assay %S		% Ret Cuml.
				Indiv.	Cuml.		Indiv.	Cuml.		Indiv.	Cuml.	
1,651	11.6	2.7	2.7	0.18	0.18	0.9	0.20	0.20	1.3	1.62	1.62	0.8
1,168	28.8	6.8	9.5	0.22	0.21	3.4	0.28	0.26	5.9	1.92	1.83	3.0
833	51.5	12.1	21.6	0.24	0.23	8.5	0.30	0.28	14.7	2.51	2.21	8.3
589	70.3	16.5	38.2	0.29	0.25	16.8	0.33	0.30	28.0	3.28	2.68	17.7
417	75.2	17.7	55.9	0.34	0.28	27.2	0.34	0.31	42.5	4.67	3.31	32.0
295	66.3	15.6	71.5	0.40	0.31	38.0	0.34	0.32	55.4	6.16	3.93	48.7
208	38.3	9.0	80.5	0.61	0.34	47.6	0.40	0.33	64.1	8.79	4.47	62.5
147	19.1	4.5	85.0	1.03	0.38	55.6	0.56	0.34	70.2	10.8	4.81	70.9
-147	63.7	15.0	100.0	1.71	0.58	100.0	0.82	0.41	100.0	11.2	5.77	100.0
Total	**424.8**	**100.0**	--	**0.58**	--	--	**0.41**	--	--	**5.77**	--	--
Direct				**0.58**			**0.40**			**5.68**		

Screen Undersize (Flotation Feed)

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni		% Ret Cuml.	Assay %Cu		% Ret Cuml.	Assay %S		% Ret Cuml.
				Indiv.	Cuml.		Indiv.	Cuml.		Indiv.	Cuml.	
208	11.6	5.4	5.4	0.49	0.49	1.8	0.72	0.72	4.6	6.14	6.14	3.9
147	16.2	7.5	12.8	0.77	0.65	5.8	0.78	0.75	11.5	7.36	6.85	10.5
104	18.0	8.3	21.2	0.97	0.78	11.3	0.73	0.75	18.7	8.06	7.33	18.6
74	21.5	9.9	31.1	1.37	0.97	20.7	0.73	0.74	27.3	9.22	7.93	29.5
53	23.4	10.8	41.9	1.56	1.12	32.2	0.71	0.73	36.4	10.3	8.54	42.8
37	19.3	8.9	50.8	2.01	1.28	44.6	0.83	0.75	45.2	11.3	9.03	54.9
-37	106.5	49.2	100.0	1.64	1.46	100.0	0.94	0.84	100.0	7.66	8.35	100.0
Total	**216.5**	**100.0**	--	**1.46**	--	--	**0.84**	--	--	**8.35**	--	--
Direct				**1.51**			**0.89**			**8.80**		

Primary Rougher Concentrate

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni Indiv.	Assay %Ni Cuml.	% Ret Cuml.	Assay %Cu Indiv.	Assay %Cu Cuml.	% Ret Cuml.	Assay %S Indiv.	Assay %S Cuml.	% Ret Cuml.
208	11.3	5.1	5.1	3.49	3.49	2.8	4.29	4.29	6.0	26.8	26.8	4.6
147	23.0	10.3	15.4	5.17	4.62	11.2	3.88	4.02	17.1	28.1	27.7	14.5
104	21.7	9.7	25.1	7.48	5.73	22.8	3.99	4.01	27.8	31.8	29.3	25.1
74	22.4	10.1	35.2	9.38	6.77	37.7	4.03	4.01	39.0	32.5	30.2	36.2
53	24.6	11.0	46.3	9.30	7.37	53.9	3.74	3.95	50.4	32.8	30.8	48.5
37	21.0	9.4	55.7	8.39	7.55	66.4	3.39	3.85	59.2	34.3	31.4	59.6
-37	98.7	44.3	100.0	4.79	6.32	100.0	3.34	3.63	100.0	26.8	29.4	100.0
Total	**222.7**	**100.0**	--	**6.32**	--	--	**3.63**	--	--	**29.4**	--	--
Direct				**6.33**			**3.60**			**28.2**		

Secondary Rougher Concentrate

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni Indiv.	Assay %Ni Cuml.	% Ret Cuml.	Assay %Cu Indiv.	Assay %Cu Cuml.	% Ret Cuml.	Assay %S Indiv.	Assay %S Cuml.	% Ret Cuml.
208	0.0	0.0	0.0	0.00	--	0.0	0.00	--	0.0	0.0	--	0.0
147	0.0	0.0	0.0	0.00	--	0.0	0.00	--	0.0	0.0	--	0.0
104	5.5	7.1	7.1	2.24	2.24	4.7	0.71	0.71	3.8	21.6	21.6	7.1
74	3.9	5.0	12.1	2.88	2.51	9.0	0.58	0.66	6.0	28.8	24.6	13.7
53	6.2	8.0	20.1	3.10	2.74	16.4	0.40	0.55	8.4	28.3	26.1	24.2
37	6.0	7.7	27.8	3.30	2.90	23.9	0.38	0.51	10.7	28.1	26.6	34.2
-37	56.2	72.2	100.0	3.54	3.36	100.0	1.63	1.32	100.0	19.7	21.6	100.0
Total	**77.8**	**100.0**	--	**3.36**	--	--	**1.32**	--	--	**21.6**	--	--
Direct				**3.33**			**1.30**			**21.8**		

Scavenger Tail

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	Weight grams	% Ret. Indiv.	% Ret Cuml.	Assay %Ni Indiv.	Assay %Ni Cuml.	% Ret Cuml.	Assay %Cu Indiv.	Assay %Cu Cuml.	% Ret Cuml.	Assay %S Indiv.	Assay %S Cuml.	% Ret Cuml.
208	24.0	9.7	9.7	0.097	0.097	6.4	0.100	0.100	17.5	0.90	0.90	14.0
147	39.9	16.1	25.8	0.086	0.090	15.8	0.072	0.083	38.5	0.83	0.86	35.5
104	31.8	12.9	38.7	0.078	0.086	22.6	0.057	0.074	51.8	0.79	0.83	51.7
74	27.1	11.0	49.7	0.076	0.084	28.3	0.044	0.067	60.5	0.59	0.78	62.1
53	23.7	9.6	59.2	0.066	0.081	32.6	0.029	0.061	65.5	0.29	0.70	66.5
37	18.0	7.3	66.5	0.074	0.080	36.3	0.023	0.057	68.5	0.20	0.65	68.9
-37	82.8	33.5	100.0	0.280	0.147	100.0	0.052	0.055	100.0	0.58	0.62	100.0
Total	**247.3**	**100.0**	--	**0.147**	--	--	**0.055**	--	--	**0.62**	--	--
Direct				**0.150**			**0.058**			**0.63**		

Primary Rougher Feed 196.98 kg/h 100% mass fraction

Particle	Solids			Nickel			Copper			Sulphur		
Size	% Ret.	Rate	% Ret.	Assay	Distribution		Assay	Distribution		Assay	Distribution	
µm	Indiv.	kg/h	Cuml.	%Ni	Indiv.	Cuml.	%Cu	Indiv.	Cuml.	%S	Indiv.	Cuml.
208	5.4	10.6	5.4	0.49	1.8	1.8	0.72	4.6	4.6	6.1	3.9	3.9
147	7.5	14.7	12.8	0.77	4.0	5.8	0.78	6.9	11.5	7.4	6.6	10.5
104	8.3	16.4	21.2	0.97	5.5	11.3	0.73	7.2	18.7	8.1	8.0	18.6
74	9.9	19.6	31.1	1.37	9.3	20.7	0.73	8.6	27.3	9.2	11.0	29.5
53	10.8	21.3	41.9	1.56	11.6	32.2	0.71	9.1	36.4	10.3	13.3	42.8
37	8.9	17.6	50.8	2.01	12.3	44.6	0.83	8.8	45.2	11.3	12.1	54.9
-37	49.2	96.9	100.0	1.64	55.4	100.0	0.94	54.8	100.0	7.7	45.1	100.0
Total	**100.0**	**197.0**	--	**1.46**	**100.0**	--	**0.84**	**100.0**	--	**8.4**	**100.0**	--

Prim. Rghr. Concentrate 28.12 kg/h 14.3% mass fraction

Particle	Solids			Nickel			Copper			Sulphur		
Size	% Ret.	Rate	% Ret.	Assay	Distribution		Assay	Distribution		Assay	Distribution	
µm	Indiv.	kg/h	Cuml.	%Ni	Indiv.	Cuml.	%Cu	Indiv.	Cuml.	%S	Indiv.	Cuml.
208	5.1	1.4	5.1	3.49	2.8	2.8	4.29	6.0	6.0	26.8	4.6	4.6
147	10.3	2.9	15.4	5.17	8.4	11.2	3.88	11.1	17.1	28.1	9.9	14.5
104	9.7	2.7	25.1	7.48	11.5	22.8	3.99	10.7	27.8	31.8	10.6	25.1
74	10.1	2.8	35.2	9.38	14.9	37.7	4.03	11.2	39.0	32.5	11.1	36.2
53	11.0	3.1	46.3	9.30	16.2	53.9	3.74	11.4	50.4	32.8	12.3	48.5
37	9.4	2.7	55.7	8.39	12.5	66.4	3.39	8.8	59.2	34.3	11.0	59.6
-37	44.3	12.5	100.0	4.79	33.6	100.0	3.34	40.8	100.0	26.8	40.4	100.0
Total	**100.0**	**28.1**	--	**6.32**	**100.0**	--	**3.63**	**100.0**	--	**29.36**	**100.0**	--

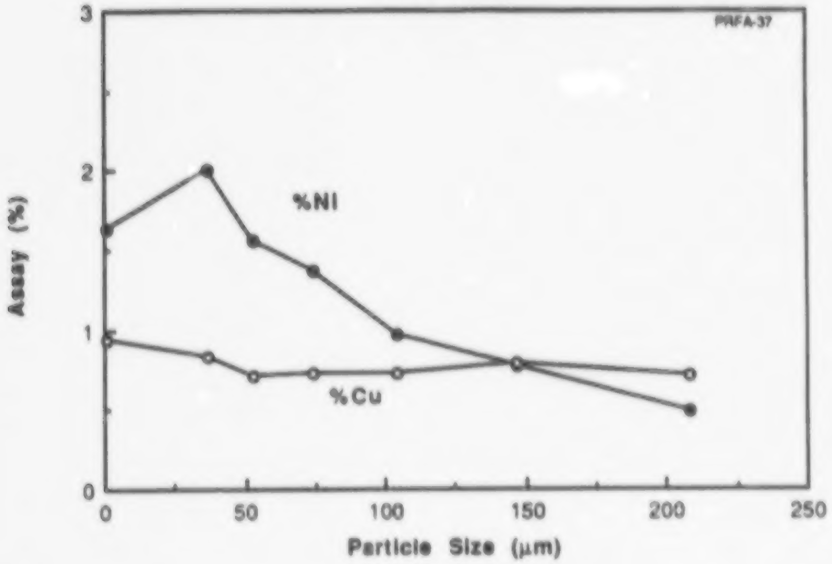
Prim. Rghr. Tail (calc) 168.86 kg/h 85.7% mass fraction

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	% Ret. Direct	Rate kg/h	% Ret. Cuml.	Assay	Distribution		Assay	Distribution		Assay	Distribution	
				%Ni	Indiv.	Cuml.	%Cu	Indiv.	Cuml.	%S	Indiv.	Cuml.
208	5.4	9.1	5.4	0.61	2.2	2.2	0.39	5.1	5.1	8.12	4.2	4.2
147	7.0	11.8	12.4	1.13	5.7	7.9	0.48	8.5	13.6	11.5	7.7	11.9
104	8.1	13.6	20.5	1.52	7.8	15.7	0.60	8.5	22.1	12.6	8.9	20.7
74	9.9	16.7	30.4	1.82	11.5	27.2	0.68	9.6	31.7	12.9	11.0	31.7
53	10.8	18.2	41.2	1.97	13.4	40.5	0.72	10.0	41.7	13.2	13.0	44.7
37	8.8	14.9	50.0	2.00	12.4	52.9	0.79	8.8	50.5	12.8	11.7	56.5
-37	50.0	84.4	100.0	1.43	47.1	100.0	0.81	49.5	100.0	8.61	43.5	100.0
Total	**100.0**	**168.9**	--	**2.75**	**100.0**	--	**1.59**	**100.0**	--	**14.64**	**100.0**	--

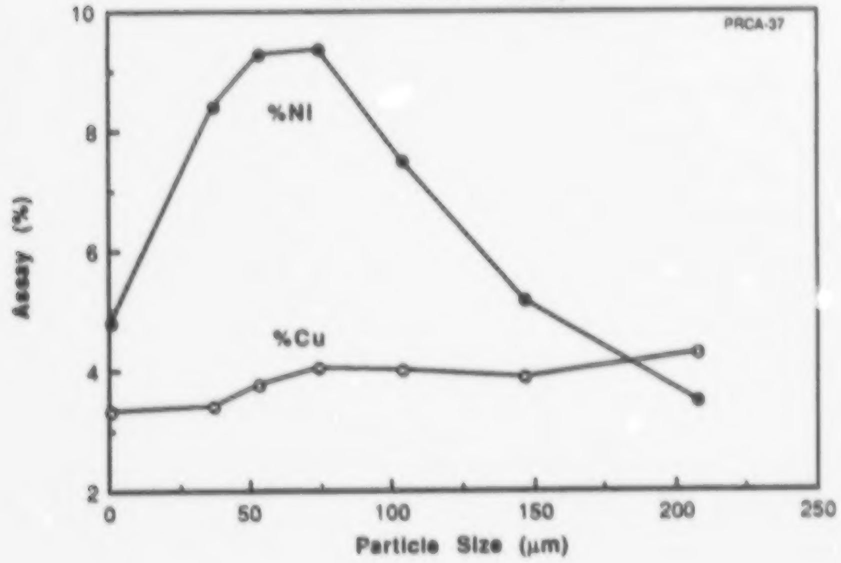
Recovery to Prim Rghr Concentrate

Size µm	Recovery to Concentrate			
	Solids Indiv.	Ni Indiv.	Cu Indiv.	S Indiv.
208	13.5	96.3	80.6	59.0
147	19.7	132.3	98.0	75.2
104	16.7	129.0	91.5	66.0
74	14.5	99.0	79.8	51.0
53	14.6	87.0	76.9	46.5
37	15.1	63.0	61.7	45.8
-37	12.9	37.6	45.7	45.0

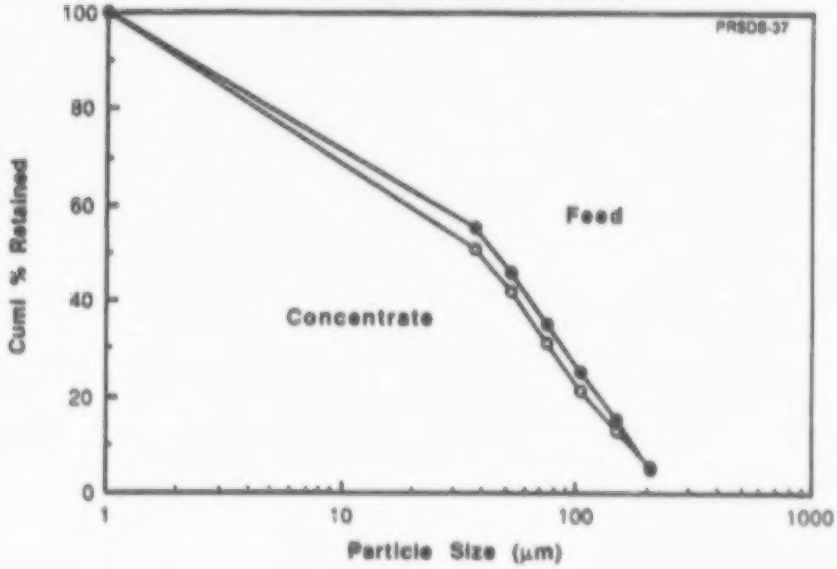
Primary Rougher
Feed Assays



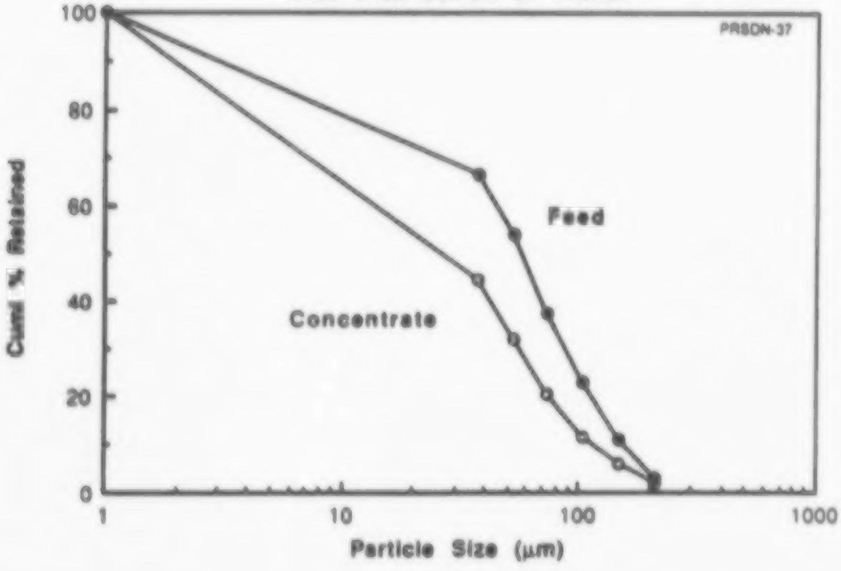
Primary Rougher
Concentrate Assays



Primary Rougher
Size Distribution of Solids



Primary Rougher
Size Distribution of Nickel



Screen Oversize 970.82 kg/h

Particle Size µm	Solids % Ret. Indiv.	Solids Rate kg/h	Solids % Ret Cuml.	Nickel Assay %Ni	Nickel Rate kg/h	Nickel % Ret Cuml.	Copper Assay %Cu	Copper Rate kg/h	Copper % Ret Cuml.	Sulphur Assay %S	Sulphur Rate kg/h	Sulphur % Ret Cuml.
1,651	3.8	37.2	3.8	0.19	0.07	1.8	0.27	0.10	3.1	1.64	0.61	1.3
1,168	8.3	80.9	12.2	0.20	0.16	6.0	0.27	0.22	9.8	1.93	1.56	4.8
833	13.8	134.0	26.0	0.23	0.31	14.1	0.31	0.42	22.5	2.49	3.34	12.1
589	19.7	191.2	45.7	0.28	0.54	28.0	0.30	0.57	40.2	3.17	6.06	25.4
417	21.5	208.5	67.1	0.34	0.71	46.4	0.31	0.65	60.0	4.57	9.53	46.4
295	17.8	173.2	85.0	0.42	0.73	65.4	0.35	0.61	78.6	6.06	10.50	69.5
208	9.1	87.9	94.0	0.56	0.49	78.2	0.39	0.34	89.1	8.42	7.40	85.8
147	2.6	25.3	96.6	1.06	0.27	85.2	0.51	0.13	93.1	11.4	2.89	92.1
-147	3.4	32.6	100.0	1.75	0.57	100.0	0.69	0.22	100.0	11.0	3.58	100.0
Total	**100.0**	**970.8**	--	**0.40**	**3.84**	--	**0.34**	**3.26**	--	**4.68**	**45.47**	--
Direct				**0.44**			**0.31**			**4.65**		

Screen Undersize 196.98 kg/h

Particle Size µm	Solids % Ret. Indiv.	Solids Rate kg/h	Solids % Ret Cuml.	Nickel Assay %Ni	Nickel Rate kg/h	Nickel % Ret Cuml.	Copper Assay %Cu	Copper Rate kg/h	Copper % Ret Cuml.	Sulphur Assay %S	Sulphur Rate kg/h	Sulphur % Ret Cuml.
208	5.4	10.6	5.4	0.49	0.05	1.8	0.72	0.08	4.6	6.14	0.65	3.9
147	7.5	14.7	12.8	0.77	0.11	5.8	0.78	0.11	11.5	7.36	1.08	10.5
104	8.3	16.4	21.2	0.97	0.16	11.3	0.73	0.12	18.7	8.06	1.32	18.6
74	9.9	19.6	31.1	1.37	0.27	20.7	0.73	0.14	27.3	9.22	1.80	29.5
53	10.8	21.3	41.9	1.56	0.33	32.2	0.71	0.15	36.4	10.3	2.19	42.8
37	8.9	17.6	50.8	2.01	0.35	44.6	0.83	0.15	45.2	11.3	1.98	54.9
-37	49.2	96.9	100.0	1.64	1.59	100.0	0.94	0.91	100.0	7.66	7.42	100.0
Total	**100.0**	**197.0**	--	**1.46**	**2.87**	--	**0.84**	**1.66**	--	**8.35**	**16.5**	--
Direct				**1.51**			**0.89**			**8.80**		

Test No. PP-37

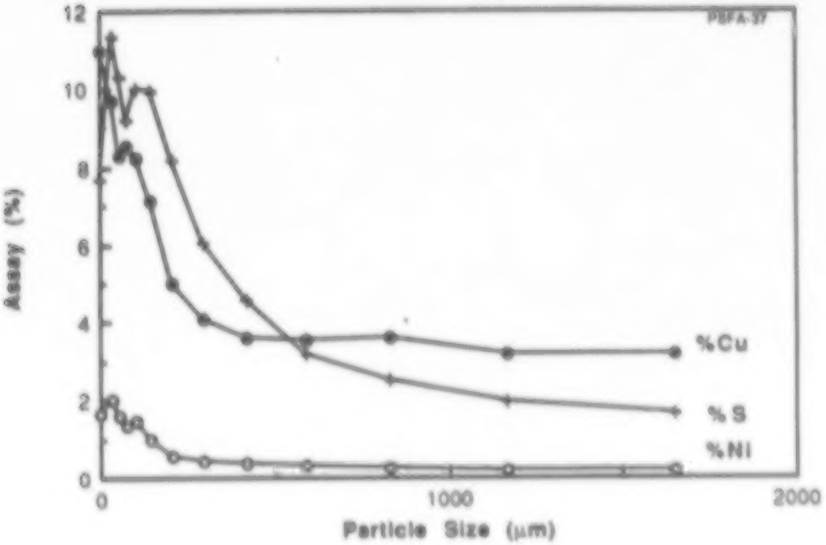
Screen Feed (calc) **1167.8 kg/h**

Particle Size µm	Solids			Nickel			Copper			Sulphur		
	% Ret. Indiv.	Rate kg/h	% Ret Cuml.	Assay %Ni	Rate kg/h	% Ret Cuml.	Assay %Cu	Rate kg/h	% Ret Cuml.	Assay %S	Rate kg/h	% Ret Cuml.
1,651	3.2	37.2	3.2	0.19	0.07	1.1	3.15	0.10	2.0	1.64	0.61	1.0
1,168	6.9	80.9	10.1	0.20	0.16	3.5	3.15	0.22	6.5	1.93	1.56	3.5
833	11.5	134.0	21.6	0.23	0.31	8.1	3.62	0.42	14.9	2.49	3.34	8.9
589	16.4	191.2	38.0	0.28	0.54	16.0	3.50	0.57	26.6	3.17	6.06	18.7
417	17.9	208.5	55.8	0.34	0.71	26.6	3.62	0.65	39.7	4.57	9.53	34.1
295	14.8	173.2	70.6	0.42	0.73	37.4	4.09	0.61	52.1	6.06	10.50	51.0
208	8.4	98.4	79.1	0.55	0.54	45.5	4.97	0.42	60.6	8.18	8.05	64.0
147	3.4	40.1	82.5	0.95	0.38	51.2	7.12	0.24	65.5	9.91	3.97	70.4
104	4.2	49.0	86.7	1.49	0.73	62.1	8.21	0.34	72.5	10.0	4.90	78.4
74	1.7	19.6	88.4	1.37	0.27	66.1	8.52	0.14	75.4	9.22	1.80	81.3
53	1.8	21.3	90.2	1.56	0.33	71.1	8.29	0.15	78.5	10.3	2.19	84.8
37	1.5	17.6	91.7	2.01	0.35	76.3	9.69	0.15	81.5	11.3	1.98	88.0
1	8.3	96.9	100.0	1.64	1.59	100.0	11.0	0.91	100.0	7.66	7.42	100.0
Total	**100.0**	**1,168**	--	**0.57**	**6.71**	--	**0.42**	**4.92**	--	**5.30**	**61.92**	--
Direct				**0.58**			**0.40**			**5.68**		

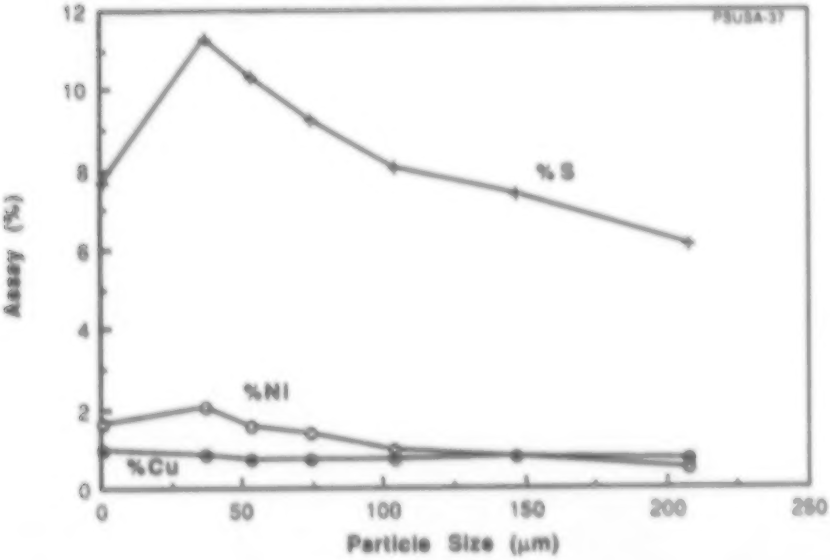
Recovery to Undersize

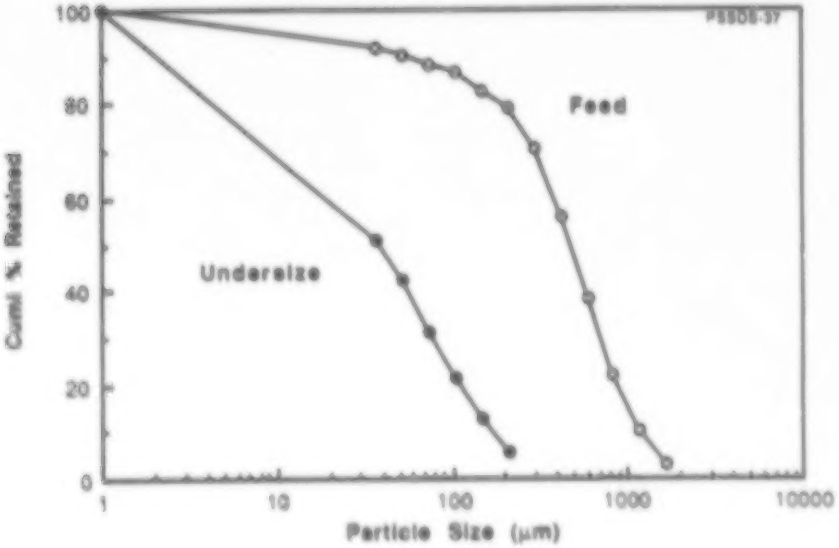
Size	Sol	Ni	Cu	S
208	10.7	9.5	18.1	8.1
147	36.8	29.7	47.1	27.3
104	33.4	21.8	34.7	26.9
74	100.0	100.0	100.0	100.0
53	100.0	100.0	100.0	100.0
37	100.0	100.0	100.0	100.0
-37	100.0	100.0	100.0	100.0

Primary Screen Feed Assays

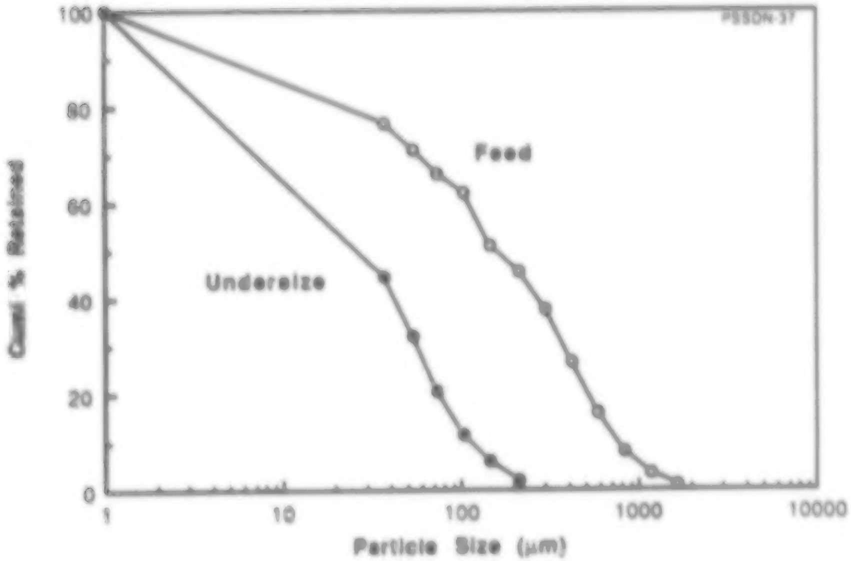


Primary Screen Undersize Assays

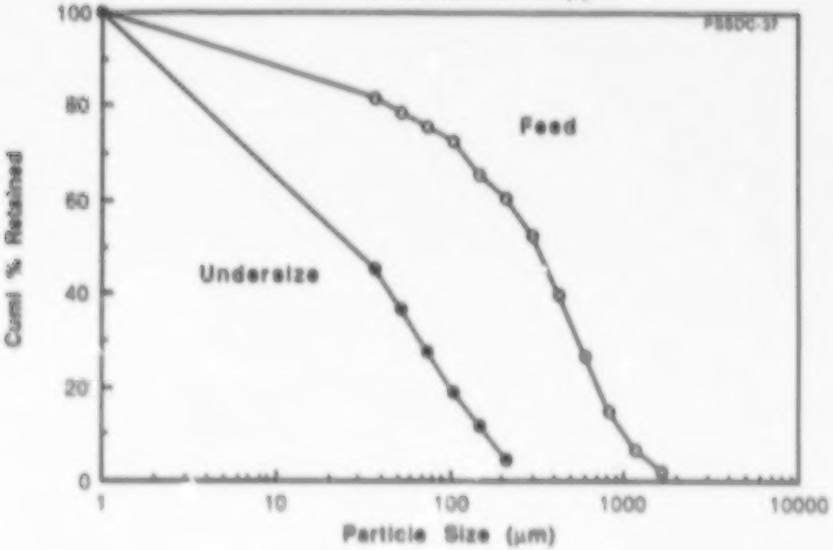




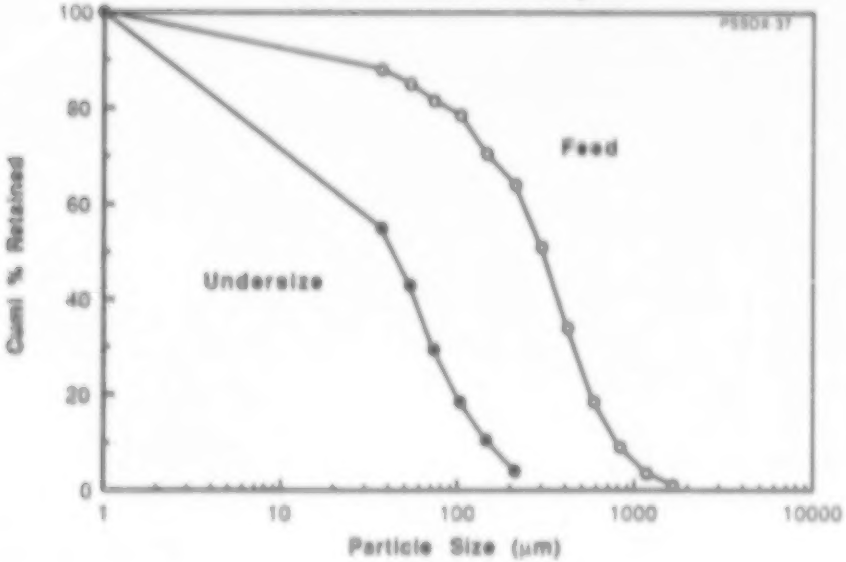
Primary Screen
Size Distribution of Solids



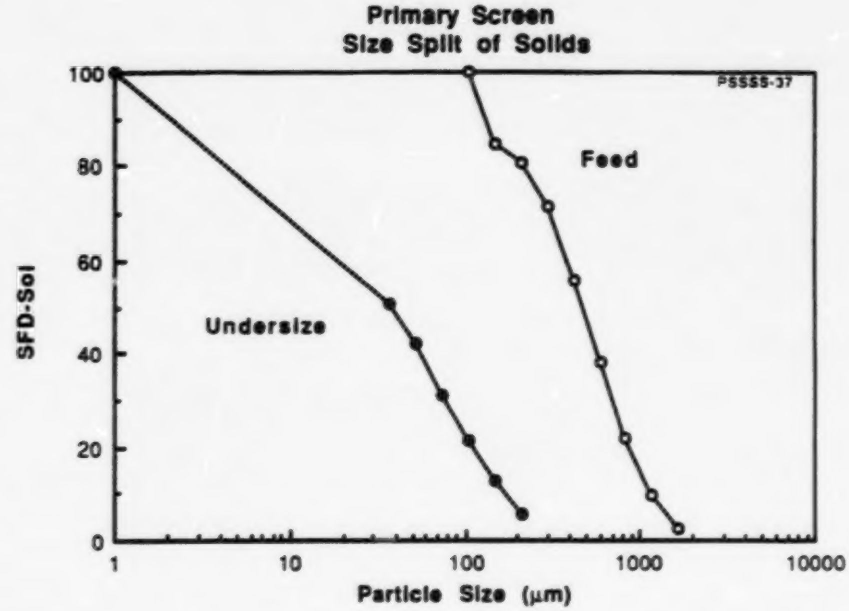
Primary Screen
Size Distribution of Nickel

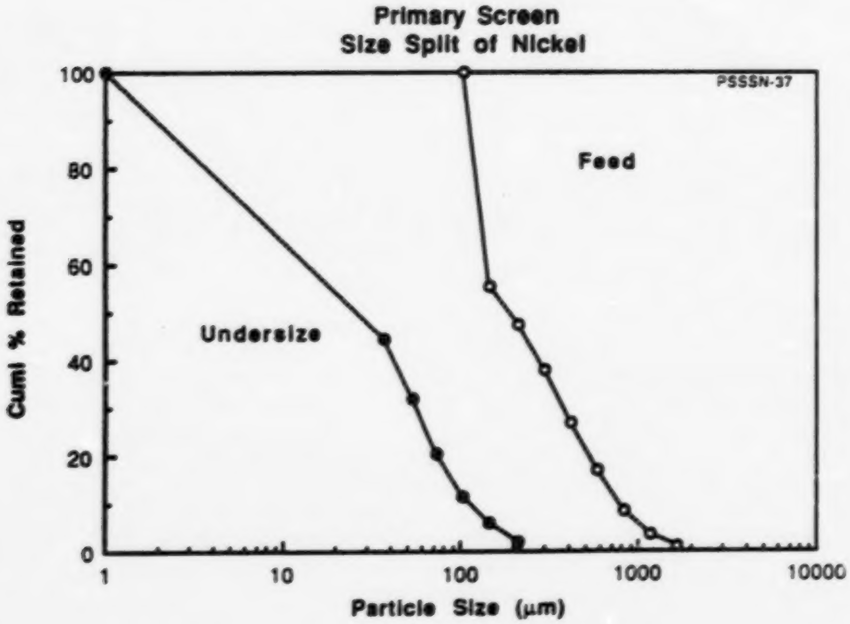


Primary Screen
Size Distribution of Copper

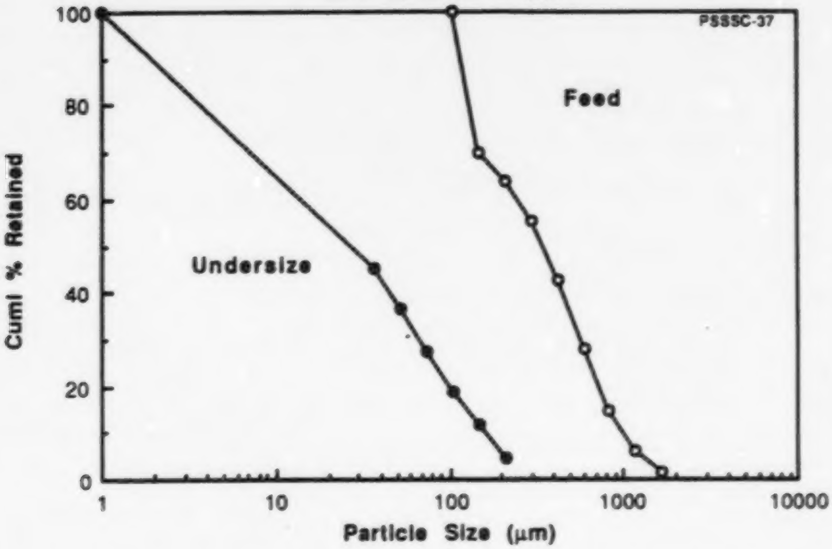


Primary Screen
Size Distribution of Sulphur

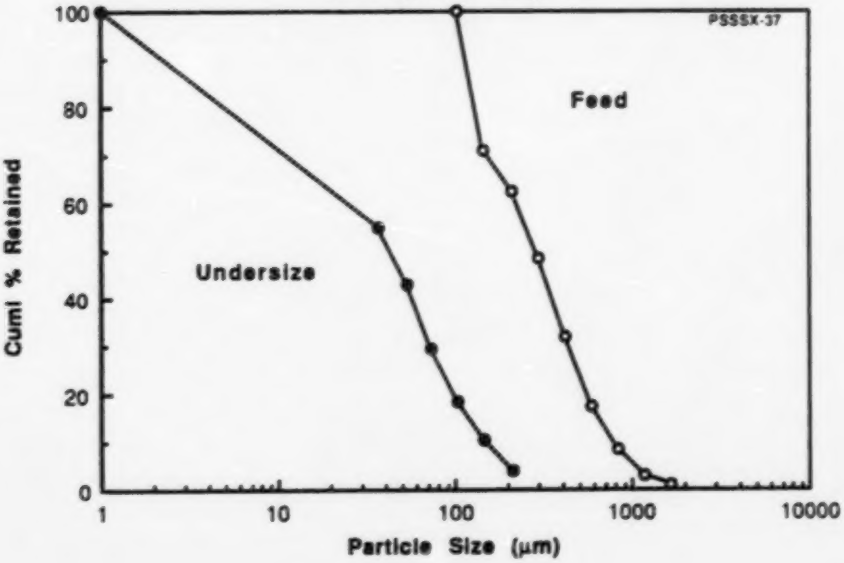

Primary Screen
Size Split of Solids
PSSSS-37
Feed
Undersize
SFD-Sol
0
20
40
60
80
100
1
10
100
1000
10000
Particle Size (μm)


Primary Screen
Size Split of Nickel
PSSSN-37
Feed
Undersize
Cuml % Retained
0
20
40
60
80
100
1
10
100
1000
10000
Particle Size (μm)

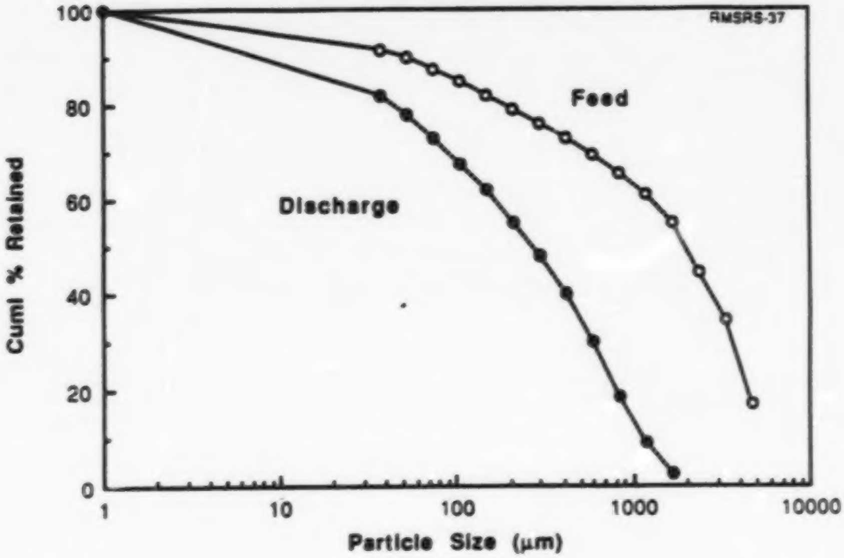
Primary Screen
Size Split of Copper



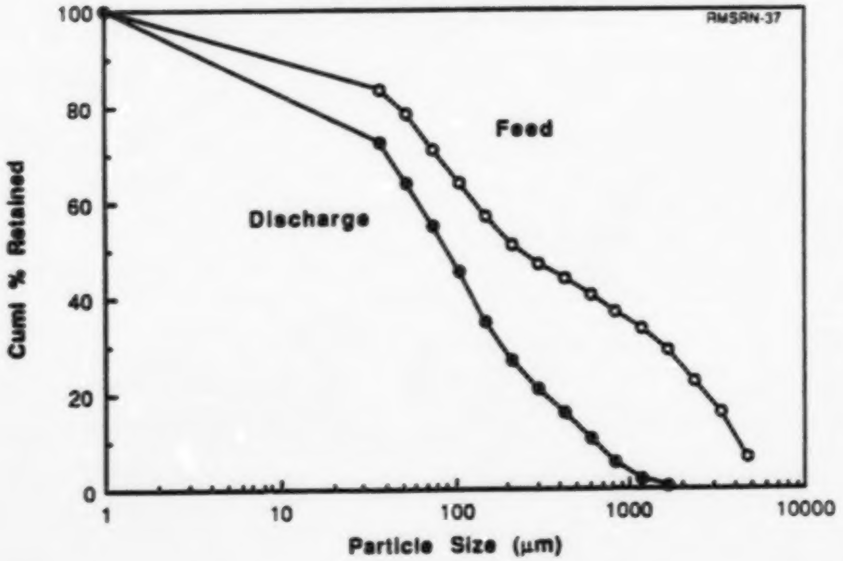
Primary Screen
Size Split of Sulphur

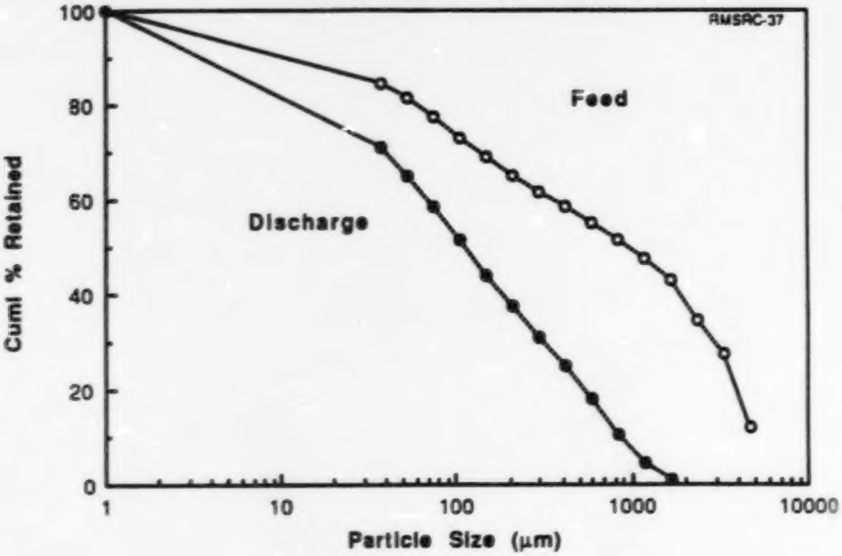


Rod Mill
Size Reduction of Solids

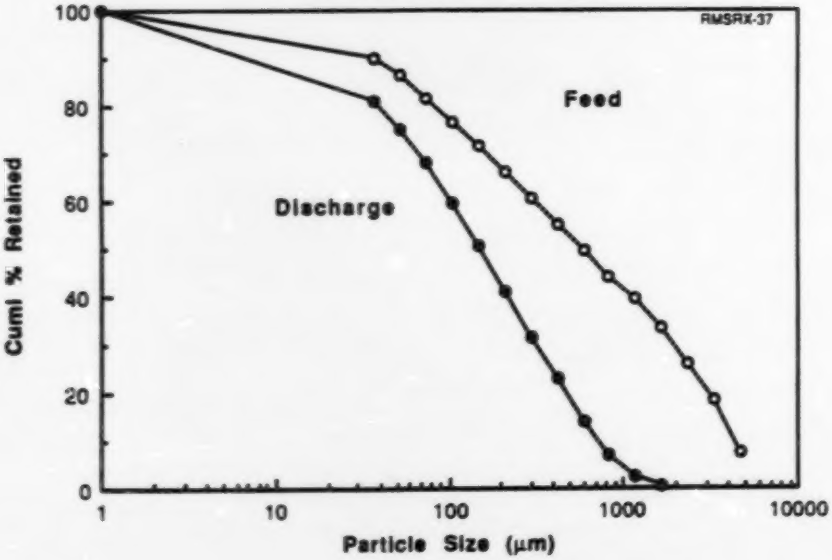


Rod Mill
Size Reduction of Nickel



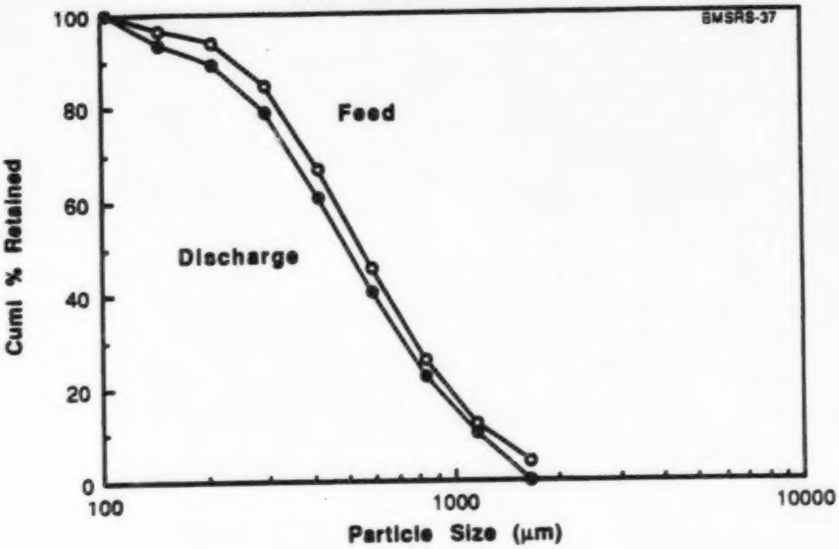


Rod Mill
Size Reduction of Copper

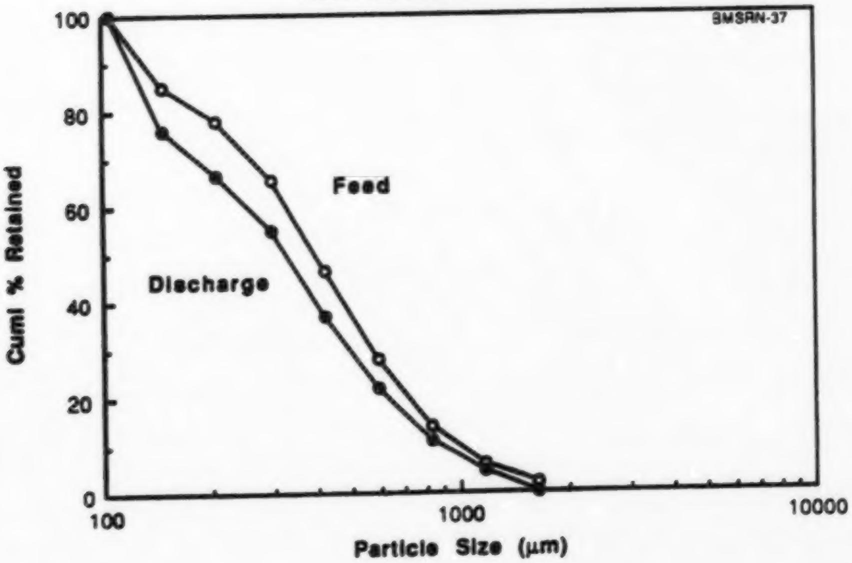


Rod Mill
Size Reduction of Sulphur

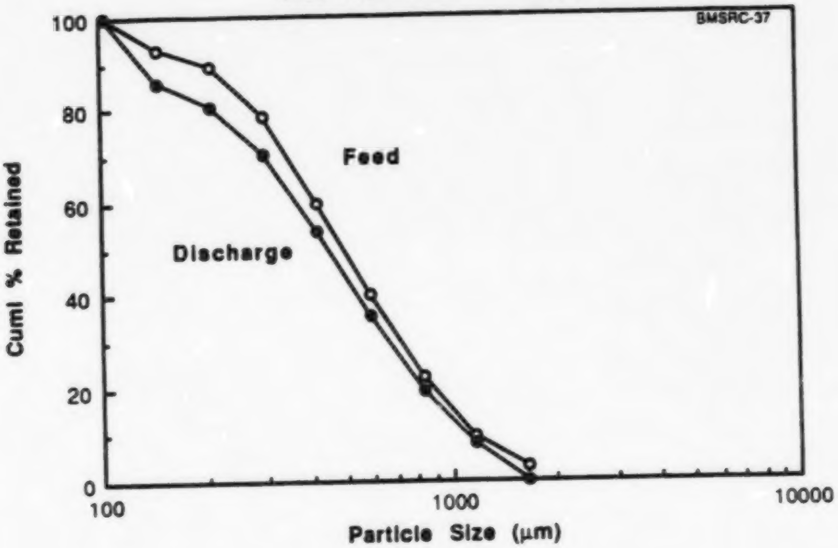
Ball Mill
Size Reduction of Solids



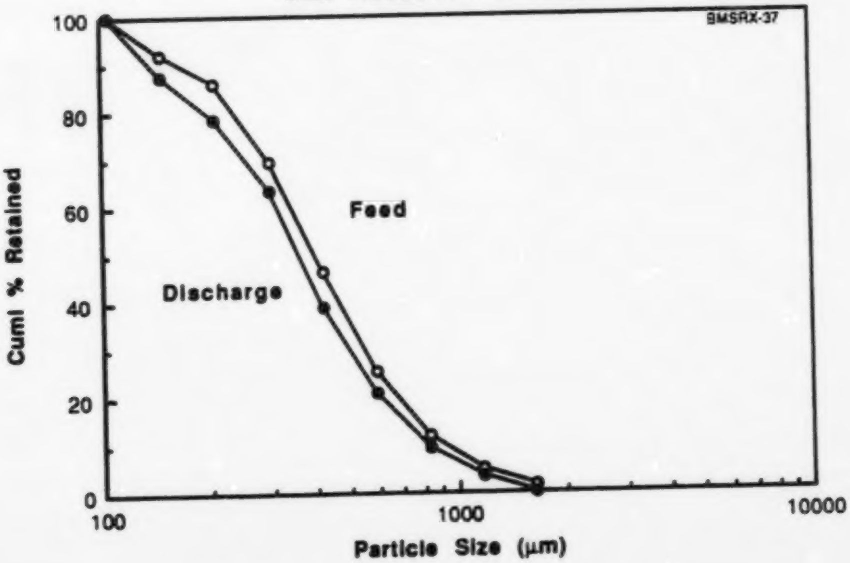
Ball Mill
Size Reduction of Nickel



Ball Mill
Size Reduction of Copper



Ball Mill
Size Reduction of Sulphur



Test No. PP-38

1. **Purpose:** To duplicate the conditions of test PP-36 in three tests per day operation.

2. **Procedure:** All process units started, including unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		77.6 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1:30	0.52	3.16	1.51	6.49
Unit Column	Grade	6.55	8.43	16.5	24.4	2.97
	Recov	4.8	15.3	4.9	15.3	0.13
Primary Rougher	Grade	5.62	2.52	14.48	7.30	3.09
	Recov	58.8	65.4	62.0	65.4	6.07
Secondary Rougher	Grade	3.63	1.62	9.09	4.71	4.74
	Recov	0.6	0.7	0.6	0.7	0.12
Scavenger	Grade	1.68	0.26	3.54	0.76	17.1
	Recov	28.0	10.8	24.1	10.8	10.08
Overall Circuit	Grade	3.29	1.33	7.99	3.85	6.81
	Recov	92.0	92.4	91.6	92.4	16.38

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	193.3 kg/h of -1/4 inch feed (Wet Sple 973.6 g)
	(Dry Sple 959.6 g)
Feed Rate:	190.5 kg/h of dry ore. (Moisture 1.44 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 837 kg in 4.33 hr
	Sample 387 kg in 2.00 hr
Rod Mill Discharge:	1,650 g/L (56 % Sol at Solid SG of 3.39)
	46.9 % plus 48 mesh
	37.9 % minus 100 mesh
Input Power:	34.13 for 3 disc revolutions
	1.14 kW (95% drive efficiency)
Average Power:	1.08 kW Gross
	0.47 kW No Load
	0.61 kW Net
Net Power Usage:	3.19 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,577 microns
K80 Product:	759 microns
Work Index (metric):	14.8

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 208 % circ. load)
Feed Rate:	396.3 kg/h
Mill Speed:	41 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,200 g/L (24 % Sol at S 3.39)
Ball Mill Discharge:	1,993 g/L (71 % Sol at S 3.39)
	66.0 % plus 48 mesh
	15.7 % minus 100 mesh
Input Power:	27.69 for 3 disc revolutions
	1.40 kW (95% drive efficiency)
Average Power:	1.33 kW Gross
	0.52 kW No Load
	0.81 kW Net
Net Power Usage:	2.05 kWh/tonne of screen oversize.
K80 Feed:	759 microns
K80 Product:	156 microns
Work Index (metric):	4.7

3.1.3. Overall Mill Report:

Net Power Usage:	5.24 kWh/t
K80 Feed:	4,577 microns
K80 Product:	156 microns
Work Index (metric):	8.0
Screen Undersize:	77.6 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	4,577	17.6
Rod Mill Discharge	759	37.9
Ball Mill Feed	932	4.8
Ball Mill Discharge	888	15.7
Column Feed	754	27.4
Column Conc	88	91.4
Screen Feed	759	21.3
Screen Undersize	156	77.6
Prim Rghr Conc	119	86.2
Sec Rghr Conc	66	90.8
Scavenger Tail	188	68.4

3.2. Reagent Additions:

Average Feed Rate: 0.191 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Column Feed	NaIX	2.0%	2.9	18.3
	DF-250	2.0%	5.0	31.5
Rougher Feed	NaIX	2.0%	5.1	32.1
	DF-250	2.0%	2.8	17.6
Scavenger 1 Feed	NaIX	2.0%	7.0	44.1
	DF-250	2.0%	2.0	12.6
	CuSO4	2.0%	6.4	40.3
Scavenger 2 Feed	NaIX	2.0%	5.0	31.5
	DF-250	2.0%	4.0	25.2
Total	**NaIX**		20.0	**126.0**
	DF-250		13.8	**86.9**
	CuSO4		6.4	**40.3**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,650			3.28
Ball Mill Discharge	1,993			
Screen Feed	1,407	9.50		
Screen Undersize	1,200	8.80	24.0	
Scavenger 1 Feed	1,175	8.60		
Scavenger 2 Tail	1,225			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	587	1.41	16.7	2.5
Primary Rougher	56	189	1.41	5.4	10.4
Secondary Rougher	28	163	1.18	10.8	2.6
Scavenger	336	163	1.23	8.4	40.2
Total	420				53.2

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 287%** **From BILCO 208%**

Product	Direct Assays			Adjusted Assays			Mass Flow kg/h	Mass % BILCO
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)		
Rod Mill Feed	1.22	0.55	9.23	1.30	0.52	9.77	190.5	100.00
Rod Mill Discharge	1.26	0.64	9.1	1.30	0.52	9.77	190.5	100.00
Ball Mill Feed	0.42	0.32	4.80	0.43	0.34	5.16	396.3	207.98
Ball Mill Discharge	0.44	0.35	5.40	0.43	0.34	5.16	396.3	207.98
Unit Column Feed	0.71	0.45	6.39	0.71	0.40	6.66	586.8	307.98
Unit Column Conc	6.66	8.14	35.30	6.55	8.43	33.7	1.8	0.95
Screen Feed	0.72	0.36	7.24	0.70	0.37	6.57	585.0	307.04
Screen Undersize	1.25	0.40	9.6	1.25	0.45	9.54	188.7	99.06
Prim Rghr Conc	6.16	2.33	27.1	5.62	2.52	25.2	25.8	13.54
Prim Rghr Tail	0.59	0.10	8.60	0.55	0.12	7.05	162.9	85.51
Sec Rghr Conc	3.62	1.63	21.7	3.63	1.62	21.9	0.4	0.22
Sec Rghr Tail	0.57	0.120	7.19	0.55	0.113	7.01	162.5	85.29
Scavenger Conc	1.62	0.280	24.2	1.68	0.262	25.6	41.1	21.56
Scavenger Tail	0.16	0.065	0.71	0.16	0.062	0.71	121.4	63.74

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)
Pentlandite % Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite % Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite % Cp = (2.90 x %Cu)
Gangue % Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.30	0.52	9.8	3.16	20.5	1.51	6.5
Combined Conc	36.3	3.29	1.33	25.7	7.99	54.4	3.85	6.8
Final Tail	63.7	0.16	0.06	0.71	0.42	1.3	0.18	3.1
Unit Column Feed	308.0	0.71	0.40	6.66	1.68	14.3	1.16	8.5
Unit Column Conc	0.9	6.55	8.43	33.67	16.46	48.8	24.45	3.0
Unit Column Tail	307.0	0.70	0.37	6.57	1.63	14.2	1.08	8.7
Prim Rghr Feed	99.1	1.25	0.45	9.54	3.04	20.3	1.29	6.7
Prim Rghr Conc	13.5	5.62	2.52	25.2	14.48	44.7	7.30	3.1
Prim Rghr Tail	85.5	0.55	0.12	7.05	1.23	16.4	0.34	13.4
Sec Rghr Feed	85.5	0.55	0.12	7.05	1.23	16.4	0.34	13.4
Sec Rghr Conc	0.2	3.63	1.62	21.9	9.09	43.1	4.71	4.7
Sec Rghr Tail	85.3	0.55	0.11	7.01	1.21	16.3	0.33	13.5
Comb Rghr Feed	99.1	1.25	0.45	9.54	3.04	20.3	1.29	6.7
Comb Rghr Conc	13.8	5.59	2.50	25.2	14.40	44.7	7.26	3.1
Comb Rghr Tail	85.3	0.55	0.11	7.01	1.21	16.3	0.33	13.5
Scavenger Feed	85.3	0.55	0.11	7.01	1.21	16.3	0.33	13.5
Scavenger Conc	21.6	1.68	0.26	25.6	3.54	60.7	0.76	17.1
Scavenger Tail	63.7	0.16	0.06	0.71	0.42	1.3	0.18	3.1
Comb Mech Feed	99.1	1.25	0.45	9.54	3.04	20.3	1.29	6.7
Comb Mech Conc	35.3	3.20	1.14	25.5	7.76	54.5	3.30	7.0
Comb Mech Tail	63.7	0.16	0.06	0.71	0.42	1.3	0.18	3.1
Col + P.Rghr Feed	100.0	1.30	0.52	9.8	3.16	20.5	1.51	6.5
Col + P.Rghr Conc	14.5	5.67	2.91	25.8	14.6	45.1	8.4	3.1
Col + P.Rghr Tail	85.5	0.55	0.12	7.0	1.23	16.4	0.34	13.4

4.3. Metallurgical Balance - Distributions:

Product	Overall Wt %	Metal Distributions (%)			Mineral Distributions (%)			Gangue
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	36.3	92.0	92.4	95.3	91.6	96.0	92.4	16.4
Final Tail	63.7	8.0	7.6	4.7	8.4	4.0	7.6	83.6
Unit Column Feed	308.0	169.6	236.5	210.2	163.4	214.4	236.5	341.2
Unit Column Conc	0.9	4.8	15.3	3.3	4.9	2.2	15.3	0.1
Unit Column Tail	307.0	164.8	221.2	206.9	158.5	212.2	221.2	341.1
Prim Rghr Feed	99.1	95.2	84.6	96.7	95.1	97.8	84.6	99.9
Prim Rghr Conc	13.5	58.8	65.4	35.0	62.0	29.5	65.4	6.1
Prim Rghr Tail	85.5	36.5	19.2	61.8	33.1	68.3	19.2	93.8
Sec Rghr Feed	85.5	36.5	19.2	61.7	33.1	68.2	19.2	93.8
Sec Rghr Conc	0.2	0.6	0.7	0.5	0.6	0.5	0.7	0.1
Sec Rghr Tail	85.3	35.9	18.5	61.2	32.5	67.7	18.5	93.7
Comb Rghr Feed	99.1	95.2	84.6	96.7	95.1	97.8	84.6	99.9
Comb Rghr Conc	13.8	59.4	66.1	35.5	62.6	29.9	66.1	6.2
Comb Rghr Tail	85.3	35.9	18.5	61.3	32.5	67.8	18.5	93.7
Scavenger Feed	85.3	36.0	18.5	61.3	32.6	67.8	18.5	93.7
Scavenger Conc	21.6	28.0	10.8	56.5	24.1	63.7	10.8	10.1
Scavenger Tail	63.7	8.0	7.7	4.7	8.4	4.0	7.7	83.6
Comb Mech Feed	99.1	95.2	84.6	96.7	95.1	97.8	84.6	99.9
Comb Mech Conc	35.3	87.3	77.0	92.1	86.7	93.8	77.0	16.2
Comb Mech Tail	63.7	8.0	7.6	4.7	8.4	4.0	7.6	83.6
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.5	63.5	80.8	38.3	66.9	31.8	80.8	6.2
Col + P.Rghr Tail	85.5	36.5	19.2	61.7	33.1	68.2	19.2	93.8

4.4. Individual Unit Performance - Distributions:

Product	Individual	Metal Distributions			Mineral Distributions			
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	36.3	92.0	92.4	95.3	91.6	96.0	92.4	16.4
Final Tail	63.7	8.0	7.6	4.7	8.4	4.0	7.6	83.6
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	0.3	2.8	6.5	1.6	3.0	1.0	6.5	0.0
Unit Column Tail	99.7	97.2	93.5	98.4	97.0	99.0	93.5	100.0
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	13.7	61.7	77.3	36.2	65.2	30.2	77.3	6.1
Prim Rghr Tail	86.3	38.3	22.7	63.8	34.8	69.8	22.7	93.9
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	0.3	1.7	3.5	0.8	1.9	0.7	3.5	0.1
Sec Rghr Tail	99.7	98.3	96.5	99.2	98.1	99.3	96.5	99.9
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	13.9	62.3	78.1	36.7	65.9	30.6	78.1	6.2
Comb Rghr Tail	86.1	37.7	21.9	63.3	34.1	69.4	21.9	93.8
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	25.3	77.8	58.6	92.3	74.1	94.0	58.6	10.8
Scavenger Tail	74.7	22.2	41.4	7.7	25.9	6.0	41.4	89.2
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	35.7	91.6	91.0	95.2	91.1	95.9	91.0	16.3
Comb Mech Tail	64.3	8.4	9.0	4.8	8.9	4.1	9.0	83.7
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.5	63.5	80.8	38.3	66.9	31.8	80.8	6.2
Col + P.Rghr Tail	85.5	36.5	19.2	61.7	33.1	68.2	19.2	93.8

5. Screen Analyses:

Detailed in the following pages.

Test No. PP-38

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	86.7	18.4	18.4	81.6
6	3,327	78.2	16.6	34.9	65.1
8	2,362	56.6	12.0	46.9	53.1
10	1,651	43.1	9.1	56.1	43.9
14	1,168	28.4	6.0	62.1	37.9
20	833	19.9	4.2	66.3	33.7
28	589	18.2	3.9	70.2	29.8
35	417	16.4	3.5	73.6	26.4
48	295	13.5	2.9	76.5	23.5
65	208	13.9	2.9	79.4	20.6
100	147	14.1	3.0	82.4	17.6
150	104	12.1	2.6	85.0	15.0
200	74	11.5	2.4	87.4	12.6
270	53	11.8	2.5	89.9	10.1
400	37	6.8	1.4	91.4	8.6
Pan	-37	40.7	8.6	100.0	-
Total	-	**471.9**	**100.0**	-	-
K80	**4,577**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	5.3	2.1	2.1	97.9
14	1,168	15.0	5.8	7.9	92.1
20	833	23.4	9.1	16.9	83.1
28	589	28.2	10.9	27.8	72.2
35	417	26.8	10.4	38.2	61.8
48	295	22.5	8.7	46.9	53.1
65	208	19.9	7.7	54.6	45.4
100	147	19.3	7.5	62.1	37.9
150	104	16.0	6.2	68.3	31.7
200	74	14.1	5.5	73.8	26.2
270	53	13.0	5.0	78.8	21.2
400	37	9.9	3.8	82.6	17.4
Pan	-37	44.8	17.4	100.0	-
Total	-	**258.2**	**100.0**	-	-
K80	**759**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	10.5	4.4	4.4	95.6
14	1,168	18.6	7.7	12.1	87.9
20	833	28.0	11.7	23.8	76.2
28	589	39.4	16.4	40.2	59.8
35	417	47.4	19.7	59.9	40.1
48	295	48.1	20.0	79.9	20.1
65	208	27.8	11.6	91.5	8.5
100	147	8.9	3.7	95.2	4.8
150	104	3.5	1.5	96.6	3.4
200	74	1.7	0.7	97.3	2.7
270	53	0.9	0.4	97.7	2.3
400	37	0.6	0.2	98.0	2.0
Pan	-37	4.9	2.0	100.0	-
Total	-	**240.3**	**100.0**	-	-
K80	**932**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	11.3	4.9	4.9	95.1
14	1,168	17.0	7.4	12.4	87.6
20	833	21.1	9.2	21.6	78.4
28	589	28.2	12.4	34.0	66.0
35	417	34.9	15.3	49.3	50.7
48	295	38.1	16.7	66.0	34.0
65	208	27.1	11.9	77.8	22.2
100	147	14.7	6.4	84.3	15.7
150	104	8.0	3.5	87.8	12.2
200	74	5.3	2.3	90.1	9.9
270	53	4.0	1.8	91.9	8.1
400	37	2.9	1.3	93.1	6.9
Pan	-37	15.7	6.9	100.0	-
Total	-	**228.3**	**100.0**	-	-
K80	**888**				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	11.0	3.2	3.2	96.8
14	1,168	19.2	5.7	8.9	91.1
20	833	27.3	8.0	16.9	83.1
28	589	37.3	11.0	27.9	72.1
35	417	44.9	13.2	41.2	58.8
48	295	46.8	13.8	55.0	45.0
65	208	36.4	10.7	65.7	34.3
100	147	23.4	6.9	72.6	27.4
150	104	16.2	4.8	77.4	22.6
200	74	13.8	4.1	81.4	18.6
270	53	10.9	3.2	84.6	15.4
400	37	9.0	2.7	87.3	12.7
Pan	-37	43.1	12.7	100.0	-
Total	-	**339.3**	**100.0**	-	-
K80	**754**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	7.4	3.8	3.8	96.2
100	147	9.3	4.8	8.6	91.4
150	104	12.1	6.2	14.9	85.1
200	74	19.6	10.1	25.0	75.0
270	53	23.7	12.2	37.2	62.8
400	37	22.5	11.6	48.8	51.2
Pan	-37	99.2	51.2	100.0	-
Total	-	**193.8**	**100.0**	-	-
K80	**88**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	9.9	2.9	2.9	97.1
14	1,168	18.2	5.4	8.4	91.6
20	833	28.4	8.4	16.8	83.2
28	589	41.6	12.4	29.2	70.8
35	417	51.3	15.2	44.4	55.6
48	295	51.2	15.2	59.6	40.4
65	208	41.4	12.3	71.9	28.1
100	147	22.7	6.7	78.7	21.3
150	104	14.4	4.3	82.9	17.1
200	74	10.9	3.2	86.2	13.8
270	53	8.5	2.5	88.7	11.3
400	37	5.9	1.8	90.5	9.5
Pan	-37	32.1	9.5	100.0	-
Total	-	**336.5**	**100.0**	-	-
K80	**759**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	9.6	8.9	8.9	91.1
100	147	14.4	13.4	22.4	77.6
150	104	12.5	11.6	34.0	66.0
200	74	11.9	11.1	45.1	54.9
270	53	10.8	10.1	55.2	44.8
400	37	8.3	7.7	62.9	37.1
Pan	-37	39.8	37.1	100.0	-
Total	-	**107.3**	**100.0**	-	-
K80	**156**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	5.7	3.9	3.9	96.1
100	147	14.5	9.9	13.8	86.2
150	104	14.9	10.2	24.0	76.0
200	74	16.0	10.9	34.9	65.1
270	53	16.6	11.3	46.2	53.8
400	37	15.3	10.4	56.7	43.3
Pan	-37	63.5	43.3	100.0	-
Total	-	**146.5**	**100.0**	-	-
K80	**119**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.6	5.7	5.7	94.3
100	147	2.2	3.5	9.2	90.8
150	104	1.7	2.7	11.9	88.1
200	74	3.4	5.4	17.2	82.8
270	53	5.2	8.2	25.5	74.5
400	37	5.0	7.9	33.4	66.6
Pan	-37	42.1	66.6	100.0	-
Total	-	**63.2**	**100.0**	-	-
K80	**66**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	27.0	14.3	14.3	85.7
100	147	32.5	17.3	31.6	68.4
150	104	24.8	13.2	44.8	55.2
200	74	21.2	11.3	56.0	44.0
270	53	17.2	9.1	65.2	34.8
400	37	12.0	6.4	71.5	28.5
Pan	-37	53.6	28.5	100.0	-
Total	-	**188.3**	**100.0**	-	-
K80	**188**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data
(based on 60 mesh Kason screen with 234 µm aperture)

C L R
287%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	46.9	66.0	79.9	0.0
-48+100	15.2	18.3	15.3	22.4
-100+200	11.7	5.8	2.2	22.7
-200+400	8.9	3.0	0.6	17.8
-400	17.4	6.9	2.0	37.1

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	337 %	61.6	208 %
-48+100	237 %	17.4	41 %
-100+200	303 %	7.3	22 %
-200+400	372 %	4.3	16 %
-400	408 %	9.5	39 %
Total		100.0	287 %

1. **Purpose:** To duplicate the conditions of test PP-36 in three tests per day operation.

2. **Procedure:** All process units started, including unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		73.5 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.33	0.63	3.23	1.84	6.69
Unit Column	Grade	7.59	12.31	19.1	35.7	2.03
	Recov	13.4	45.5	13.9	45.5	0.20
Primary Rougher	Grade	5.89	2.17	15.19	6.29	3.24
	Recov	52.5	40.6	55.7	40.6	4.75
Secondary Rougher	Grade	3.06	1.11	7.61	3.21	5.41
	Recov	0.6	0.5	0.6	0.5	0.18
Scavenger	Grade	1.57	0.21	3.22	0.61	19.3
	Recov	26.4	7.4	22.3	7.4	10.43
Overall Circuit	Grade	3.35	1.62	8.11	4.69	6.94
	Recov	92.8	93.9	92.4	93.9	15.55

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	194.5 kg/h of -1/4 inch feed (Wet Sple 1332.3 g) (Dry Sple 1319.7 g)
Feed Rate:	192.6 kg/h of dry ore. (Moisture 0.95 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 860 kg in 4.42 hr Sample 389 kg in 2.00 hr
Rod Mill Discharge:	1,710 g/L (59 % Sol at Solid SG of 3.34) 40.0 % plus 48 mesh 42.7 % minus 100 mesh
Input Power:	33.52 for 3 disc revolutions 1.16 kW (95% drive efficiency)
Average Power:	1.10 kW Gross 0.47 kW No Load 0.63 kW Net
Net Power Usage:	3.26 kWh/tonne of -1/4 inch feed.
K80 Feed:	3,983 microns
K80 Product:	553 microns
Work Index (metric):	12.2

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 197 % circ. load)
Feed Rate:	379.3 kg/h
Mill Speed:	41 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,186 g/L (22 % Sol at S'3.34)
Ball Mill Discharge:	1,462 g/L (45 % Sol at S'3.34) 65.1 % plus 48 mesh 15.4 % minus 100 mesh
Input Power:	28.14 for 3 disc revolutions 1.38 kW (95% drive efficiency)
Average Power:	1.31 kW Gross 0.52 kW No Load 0.79 kW Net
Net Power Usage:	2.08 kWh/tonne of screen oversize.
K80 Feed:	553 microns
K80 Product:	173 microns
Work Index (metric):	6.2

3.1.3. Overall Mill Report:

Net Power Usage:	5.34 kWh/t
K80 Feed:	3,983 microns
K80 Product:	173 microns
Work Index (metric):	8.9
Screen Undersize:	73.5 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (µm)	%-100 m
Rod Mill Feed	3,983	19.7
Rod Mill Discharge	553	42.7
Ball Mill Feed	817	4.0
Ball Mill Discharge	733	15.4
Column Feed	668	27.3
Column Conc	88	90.8
Screen Feed	666	25.1
Screen Undersize	173	73.5
Prim Rghr Conc	105	88.0
Sec Rghr Conc	50	95.0
Scavenger Tail	178	71.9

3.2. Reagent Additions:

Average Feed Rate: 0.193 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Column Feed	NaIX	2.0%	3.0	18.7
	DF-250	2.0%	5.2	32.4
Rougher Feed	NaIX	2.0%	5.0	31.1
	DF-250	2.0%	3.0	18.7
Scavenger 1 Feed	NaIX	2.0%	7.0	43.6
	DF-250	2.0%	2.0	12.5
	CuSO4	2.0%	6.3	39.2
Scavenger 2 Feed	NaIX	2.0%	5.0	31.1
	DF-250	2.0%	4.0	24.9
Total	**NaIX**		20.0	**124.6**
	DF-250		14.2	**88.5**
	CuSO4		6.3	**39.2**

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,710			3.34
Ball Mill Discharge	1,462			
Screen Feed	1,474	9.54		
Screen Undersize	1,186	9.16	23.0	
Scavenger 1 Feed	1,208	8.37		
Scavenger 2 Tail	1,293			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	572	1.47	14.1	2.9
Primary Rougher	56	188	1.47	4.6	12.1
Secondary Rougher	28	165	1.21	9.3	3.0
Scavenger	336	165	1.29	6.6	51.2
Total	420				66.3

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 225%** **From BILCO 197%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.24	0.64	9.99	1.33	0.63	10.34	192.6	100.00
Rod Mill Discharge	1.33	0.65	10.4	1.33	0.63	10.34	192.6	100.00
Ball Mill Feed	0.41	0.31	5.12	0.42	0.30	5.15	379.3	196.92
Ball Mill Discharge	0.42	0.29	5.11	0.42	0.30	5.15	379.3	196.92
Unit Column Feed	0.77	0.41	7.01	0.73	0.41	6.90	572.0	296.92
Unit Column Conc	7.73	12.1	35.0	7.59	12.31	34.66	4.5	2.34
Screen Feed	0.65	0.31	6.65	0.67	0.32	6.68	567.5	294.58
Screen Undersize	1.29	0.36	10.9	1.18	0.35	9.76	188.1	97.66
Prim Rghr Conc	6.07	2.12	26.4	5.89	2.17	26.85	22.8	11.85
Prim Rghr Tail	0.52	0.10	7.20	0.53	0.10	7.39	165.3	85.81
Sec Rghr Conc	3.05	1.11	19.9	3.06	1.11	20.06	0.5	0.27
Sec Rghr Tail	0.58	0.093	8.38	0.52	0.10	7.35	164.8	85.54
Scavenger Conc	1.51	0.230	23.8	1.57	0.21	25.97	43.1	22.39
Scavenger Tail	0.15	0.065	0.75	0.15	0.06	0.76	121.7	63.16

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.33	0.63	10.3	3.23	21.6	1.84	6.7
Combined Conc	36.8	3.35	1.62	26.8	8.11	56.3	4.69	6.9
Final Tail	63.2	0.15	0.06	0.76	0.39	1.4	0.18	3.6
Unit Column Feed	296.9	0.73	0.41	6.90	1.70	14.8	1.19	8.7
Unit Column Conc	2.3	7.59	12.31	34.66	19.15	38.9	35.71	2.0
Unit Column Tail	294.6	0.67	0.32	6.68	1.56	14.6	0.92	9.4
Prim Rghr Feed	97.7	1.18	0.35	9.76	2.85	21.2	1.03	7.4
Prim Rghr Conc	11.9	5.89	2.17	26.9	15.19	49.1	6.29	3.2
Prim Rghr Tail	85.8	0.53	0.10	7.39	1.15	17.4	0.30	15.1
Sec Rghr Feed	85.8	0.53	0.10	7.39	1.15	17.4	0.30	15.1
Sec Rghr Conc	0.3	3.06	1.11	20.1	7.61	41.2	3.21	5.4
Sec Rghr Tail	85.5	0.52	0.10	7.35	1.13	17.3	0.29	15.3
Comb Rghr Feed	97.7	1.18	0.35	9.76	2.85	21.2	1.03	7.4
Comb Rghr Conc	12.1	5.83	2.15	26.7	15.02	49.0	6.22	3.3
Comb Rghr Tail	85.5	0.52	0.10	7.35	1.13	17.3	0.29	15.3
Scavenger Feed	85.5	0.52	0.10	7.35	1.13	17.3	0.29	15.3
Scavenger Conc	22.4	1.57	0.21	26.0	3.22	62.0	0.61	19.3
Scavenger Tail	63.2	0.15	0.06	0.76	0.39	1.4	0.18	3.6
Comb Mech Feed	97.7	1.18	0.35	9.76	2.85	21.2	1.03	7.4
Comb Mech Conc	34.5	3.06	0.89	26.2	7.36	57.4	2.58	7.8
Comb Mech Tail	63.2	0.15	0.06	0.76	0.39	1.4	0.18	3.6
Col + P.Rghr Feed	100.0	1.33	0.63	10.3	3.23	21.6	1.84	6.7
Col + P.Rghr Conc	14.2	6.17	3.84	28.1	15.8	47.5	11.1	3.0
Col + P.Rghr Tail	85.8	0.53	0.10	7.4	1.15	17.4	0.30	15.1

4.3. Metallurgical Balance - Distributions:

Product	Overall Wt %	Metal Distributions (%)			Mineral Distributions (%)			Gangue
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	36.8	92.8	93.9	95.4	92.4	95.9	93.9	15.5
Final Tail	63.2	7.2	6.1	4.6	7.6	4.1	6.1	84.5
Unit Column Feed	296.9	161.7	192.5	198.1	156.2	203.8	192.5	333.2
Unit Column Conc	2.3	13.4	45.5	7.8	13.9	4.2	45.5	0.2
Unit Column Tail	294.6	148.4	147.0	190.3	142.4	199.6	147.0	333.0
Prim Rghr Feed	97.7	86.7	54.5	92.2	86.1	95.8	54.5	99.8
Prim Rghr Conc	11.9	52.5	40.6	30.8	55.7	26.9	40.6	4.7
Prim Rghr Tail	85.8	34.2	14.0	61.4	30.5	68.9	14.0	95.1
Sec Rghr Feed	85.8	34.2	13.9	61.4	30.5	68.9	13.9	95.1
Sec Rghr Conc	0.3	0.6	0.5	0.5	0.6	0.5	0.5	0.2
Sec Rghr Tail	85.5	33.6	13.5	60.9	29.9	68.3	13.5	94.9
Comb Rghr Feed	97.7	86.7	54.5	92.2	86.1	95.8	54.5	99.8
Comb Rghr Conc	12.1	53.1	41.0	31.3	56.3	27.4	41.0	4.9
Comb Rghr Tail	85.5	33.6	13.5	60.8	29.8	68.3	13.5	94.9
Scavenger Feed	85.5	33.6	13.5	60.8	29.9	68.3	13.5	94.9
Scavenger Conc	22.4	26.4	7.4	56.2	22.3	64.2	7.4	10.4
Scavenger Tail	63.2	7.2	6.0	4.6	7.6	4.1	6.0	84.5
Comb Mech Feed	97.7	86.7	54.5	92.2	86.1	95.8	54.5	99.8
Comb Mech Conc	34.5	79.4	48.5	87.5	78.5	91.7	48.5	15.4
Comb Mech Tail	63.2	7.2	6.1	4.6	7.6	4.1	6.1	84.5
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.2	65.8	86.1	38.6	69.5	31.1	86.1	4.9
Col + P.Rghr Tail	85.8	34.2	13.9	61.4	30.5	68.9	13.9	95.1

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	36.8	92.8	93.9	95.4	92.4	95.9	93.9	15.5
Final Tail	63.2	7.2	6.1	4.6	7.6	4.1	6.1	84.5
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	0.8	8.3	23.6	4.0	8.9	2.1	23.6	0.1
Unit Column Tail	99.2	91.7	76.4	96.0	91.1	97.9	76.4	99.9
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	12.1	60.5	74.4	33.4	64.6	28.1	74.4	4.8
Prim Rghr Tail	87.9	39.5	25.6	66.6	35.4	71.9	25.6	95.2
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	0.3	1.8	3.4	0.9	2.1	0.7	3.4	0.2
Sec Rghr Tail	99.7	98.2	96.6	99.1	97.9	99.3	96.6	99.8
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	12.4	61.2	75.2	34.0	65.4	28.7	75.2	4.9
Comb Rghr Tail	87.6	38.8	24.8	66.0	34.6	71.3	24.8	95.1
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	26.2	78.6	55.2	92.4	74.6	94.0	55.2	11.0
Scavenger Tail	73.8	21.4	44.8	7.6	25.4	6.0	44.8	89.0
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	35.3	91.7	88.9	95.0	91.2	95.7	88.9	15.4
Comb Mech Tail	64.7	8.3	11.1	5.0	8.8	4.3	11.1	84.6
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	14.2	65.8	86.1	38.6	69.5	31.1	86.1	4.9
Col + P.Rghr Tail	85.8	34.2	13.9	61.4	30.5	68.9	13.9	95.1

5. Screen Analyses:

Detailed in the following pages.

Test No. PP-39

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	101.5	13.7	13.7	86.3
6	3,327	95.6	12.9	26.6	73.4
8	2,362	78.4	10.6	37.2	62.8
10	1,651	79.8	10.8	47.9	52.1
14	1,168	54.3	7.3	55.2	44.8
20	833	40.3	5.4	60.7	39.3
28	589	35.9	4.8	65.5	34.5
35	417	32.3	4.4	69.9	30.1
48	295	26.2	3.5	73.4	26.6
65	208	25.6	3.5	76.9	23.1
100	147	25.7	3.5	80.3	19.7
150	104	21.6	2.9	83.2	16.8
200	74	19.3	2.6	85.8	14.2
270	53	19.6	2.6	88.5	11.5
400	37	14.0	1.9	90.4	9.6
Pan	-37	71.4	9.6	100.0	-
Total	-	**741.5**	**100.0**	-	-
K80	**3,983**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	1.3	0.5	0.5	99.5
14	1,168	4.3	1.5	2.0	98.0
20	833	13.7	4.8	6.8	93.2
28	589	30.2	10.6	17.4	82.6
35	417	35.9	12.6	30.0	70.0
48	295	28.2	9.9	40.0	60.0
65	208	25.5	9.0	48.9	51.1
100	147	23.7	8.3	57.3	42.7
150	104	19.5	6.9	64.1	35.9
200	74	17.3	6.1	70.2	29.8
270	53	15.5	5.5	75.7	24.3
400	37	12.4	4.4	80.0	20.0
Pan	-37	56.8	20.0	100.0	-
Total	-	**284.3**	**100.0**	-	-
K80	**553**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	8.6	2.7	2.7	97.3
14	1,168	19.4	6.0	8.6	91.4
20	833	34.6	10.7	19.3	80.7
28	589	55.2	17.0	36.4	63.6
35	417	71.0	21.9	58.3	41.7
48	295	72.2	22.3	80.6	19.4
65	208	38.6	11.9	92.5	7.5
100	147	11.3	3.5	96.0	4.0
150	104	3.7	1.1	97.1	2.9
200	74	1.6	0.5	97.6	2.4
270	53	1.0	0.3	97.9	2.1
400	37	0.7	0.2	98.1	1.9
Pan	-37	6.1	1.9	100.0	-
Total	-	**324.0**	**100.0**	-	-
K80	**817**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	7.4	2.6	2.6	97.4
14	1,168	13.0	4.7	7.3	92.7
20	833	22.1	7.9	15.2	84.8
28	589	36.8	13.2	28.4	71.6
35	417	50.5	18.1	46.4	53.6
48	295	52.1	18.6	65.1	34.9
65	208	37.7	13.5	78.6	21.4
100	147	16.9	6.0	84.6	15.4
150	104	9.2	3.3	87.9	12.1
200	74	6.4	2.3	90.2	9.8
270	53	4.8	1.7	91.9	8.1
400	37	3.3	1.2	93.1	6.9
Pan	-37	19.3	6.9	100.0	-
Total	-	**279.5**	**100.0**	-	-
K80	**733**				

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	6.0	1.5	1.5	98.5
14	1,168	14.1	3.6	5.2	94.8
20	833	26.9	6.9	12.1	87.9
28	589	47.4	12.2	24.3	75.7
35	417	59.8	15.4	39.7	60.3
48	295	59.0	15.2	54.8	45.2
65	208	42.9	11.0	65.9	34.1
100	147	26.4	6.8	72.7	27.3
150	104	18.5	4.8	77.4	22.6
200	74	15.5	4.0	81.4	18.6
270	53	13.5	3.5	84.9	15.1
400	37	10.2	2.6	87.5	12.5
Pan	-37	48.6	12.5	100.0	-
Total	-	**388.8**	**100.0**	-	-
K80	**668**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	3.7	3.9	3.9	96.1
100	147	5.0	5.3	9.2	90.8
150	104	6.3	6.7	15.9	84.1
200	74	8.1	8.6	24.4	75.6
270	53	10.7	11.3	35.7	64.3
400	37	10.8	11.4	47.1	52.9
Pan	-37	50.0	52.9	100.0	-
Total	-	**94.6**	**100.0**	-	-
K80	**88**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	5.4	1.6	1.6	98.4
14	1,168	12.4	3.7	5.3	94.7
20	833	22.6	6.7	12.1	87.9
28	589	40.0	11.9	24.0	76.0
35	417	53.7	16.0	40.0	60.0
48	295	52.7	15.7	55.8	44.2
65	208	40.8	12.2	68.0	32.0
100	147	23.3	7.0	74.9	25.1
150	104	15.6	4.7	79.6	20.4
200	74	12.3	3.7	83.2	16.8
270	53	9.5	2.8	86.1	13.9
400	37	7.8	2.3	88.4	11.6
Pan	-37	38.8	11.6	100.0	-
Total	-	**334.9**	**100.0**	-	-
K80	**666**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	19.1	11.9	11.9	88.1
100	147	23.3	14.6	26.5	73.5
150	104	19.4	12.1	38.6	61.4
200	74	17.4	10.9	49.5	50.5
270	53	14.5	9.1	58.6	41.4
400	37	11.9	7.4	66.0	34.0
Pan	-37	54.4	34.0	100.0	-
Total	-	**160.0**	**100.0**	-	-
K80	**173**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	4.7	3.2	3.2	96.8
100	147	12.8	8.8	12.0	88.0
150	104	13.0	8.9	20.9	79.1
200	74	13.6	9.3	30.2	69.8
270	53	51.1	35.0	65.2	34.8
400	37	14.4	9.9	75.1	24.9
Pan	-37	36.4	24.9	100.0	-
Total	-	**146.0**	**100.0**	-	-
K80	**105**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.2	3.1	3.1	96.9
100	147	1.4	2.0	5.0	95.0
150	104	1.4	2.0	7.0	93.0
200	74	3.0	4.2	11.2	88.8
270	53	5.6	7.8	19.0	81.0
400	37	5.4	7.6	26.6	73.4
Pan	-37	52.5	73.4	100.0	-
Total	-	**71.5**	**100.0**	-	-
K80	**50**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	15.3	12.7	12.7	87.3
100	147	18.6	15.4	28.1	71.9
150	104	15.1	12.5	40.6	59.4
200	74	13.1	10.9	51.4	48.6
270	53	11.2	9.3	60.7	39.3
400	37	8.3	6.9	67.6	32.4
Pan	-37	39.1	32.4	100.0	-
Total	-	**120.7**	**100.0**	-	-
K80	**178**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data

(based on 60 mesh Kason screen with 234 μm aperture)

C L R
225%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	40.0	65.1	80.6	0.0
-48+100	17.3	19.5	15.4	26.5
-100+200	12.9	5.6	1.6	23.0
-200+400	9.8	2.9	0.5	16.5
-400	20.0	6.9	1.9	34.0

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	258 %	58.1	150 %
-48+100	222 %	18.8	42 %
-100+200	255 %	7.7	20 %
-200+400	282 %	4.7	13 %
-400	279 %	10.7	30 %
Total		100.0	**225 %**

1. **Purpose:** To duplicate the conditions of test PP-36 in three tests per day operation.

2. **Procedure:** All process units started, including unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		79.3 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.35	0.63	3.38	1.82	4.86
Unit Column	Grade	8.56	8.50	21.7	24.6	3.00
	Recov	22.5	48.1	22.8	48.1	-0.52
Primary Rougher	Grade	4.97	1.83	12.39	5.29	5.32
	Recov	50.2	39.6	50.0	39.6	2.85
Secondary Rougher	Grade	3.52	1.20	9.03	3.49	3.68
	Recov	3.0	2.2	3.0	2.2	0.79
Scavenger	Grade	1.82	0.18	4.38	0.53	7.9
	Recov	14.5	3.2	14.0	3.2	8.34
Overall Circuit	Grade	4.14	2.01	10.30	5.83	5.15
	Recov	89.2	93.1	88.7	93.1	11.46

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	195.4 kg/h of -1/4 inch feed. (Wet Sple 1232.8 g)
	(Dry Sple 1215.2 g)
Feed Rate:	192.7 kg/h of dry ore. (Moisture 1.43 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 864 kg in 4.42 hr
	Sample 391 kg in 2.00 hr
Rod Mill Discharge:	1,690 g/L (58 % Sol at Solid SG of 3.34)
	38.6 % plus 48 mesh
	43.2 % minus 100 mesh
Input Power:	33.74 for 3 disc revolutions
	1.15 kW (95% drive efficiency)
Average Power:	1.09 kW Gross
	0.47 kW No Load
	0.62 kW Net
Net Power Usage:	3.22 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,401 microns
K80 Product:	516 microns
Work Index (metric):	11.1

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 287 % circ. load)
Feed Rate:	553.5 kg/h
Mill Speed:	41 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,175 g/L (21 % Sol at S' 3.34)
Ball Mill Discharge:	1,547 g/L (50 % Sol at S' 3.34)
	76.9 % plus 48 mesh
	2.8 % minus 100 mesh
Input Power:	27.53 for 3 disc revolutions
	1.41 kW (95% drive efficiency)
Average Power:	1.34 kW Gross
	0.52 kW No Load
	0.82 kW Net
Net Power Usage:	1.48 kWh/tonne of screen oversize.
K80 Feed:	516 microns
K80 Product:	150 microns
Work Index (metric):	3.9

3.1.3. Overall Mill Report:

Net Power Usage:	4.70 kWh/t
K80 Feed:	4,401 microns
K80 Product:	150 microns
Work Index (metric):	7.1
Screen Undersize:	79.3 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	4,401	19.0
Rod Mill Discharge	516	43.2
Ball Mill Feed	734	4.5
Ball Mill Discharge	745	2.8
Column Feed	705	21.5
Column Conc	109	87.4
Screen Feed	724	15.3
Screen Undersize	150	79.3
Prim Rghr Conc	132	83.0
Sec Rghr Conc	53	94.2
Scavenger Tail	174	72.9

3.2. Reagent Additions:

Average Feed Rate: 0.193 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Column Feed	NaIX	2.0%	2.9	18.1
	DF-250	2.0%	5.0	31.1
Rougher Feed	NaIX	2.0%	5.0	31.1
	DF-250	2.0%	2.9	18.1
Scavenger 1 Feed	NaIX	2.0%	7.1	44.2
	DF-250	2.0%	2.0	12.5
	CuSO4	2.0%	6.0	37.4
Scavenger 2 Feed	NaIX	2.0%	4.8	29.9
	DF-250	2.0%	4.1	25.5
Total	NaIX		19.8	123.3
	DF-250		14.0	87.2
	CuSO4		6.0	37.4

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,690			3.36
Ball Mill Discharge	1,547			
Screen Feed	1,650	9.35		
Screen Undersize	1,175	9.10	24.0	
Scavenger 1 Feed	1,150	8.83		
Scavenger 2 Tail	1,231			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	746	1.65	13.4	3.1
Primary Rougher	56	186	1.65	3.3	16.7
Secondary Rougher	28	159	1.15	12.4	2.3
Scavenger	336	156	1.23	7.9	42.4
Total	420				61.4

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **Avg (39 & 41) 280%** **From BILCO 276%**

Product	Direct Assays			Adjusted Assays			Mass Flow	Mass %
	% Ni	% Cu	% S(T)	% Ni	% Cu	% S(T)	kg/h	BILCO
Rod Mill Feed	1.21	0.62	9.50	1.35	0.63	8.32	192.7	100.00
Rod Mill Discharge	1.44	0.68	10.7	1.35	0.63	8.32	192.7	100.00
Ball Mill Feed	0.51	0.34	6.69	0.45	0.33	5.49	531.2	275.73
Ball Mill Discharge	0.41	0.33	5.30	0.45	0.33	5.49	531.2	275.73
Unit Column Feed	0.65	0.44	6.14	0.69	0.41	6.24	723.9	375.73
Unit Column Conc	9.06	8.22	35.9	8.56	8.50	42.0	6.9	3.56
Screen Feed	0.64	0.31	5.18	0.61	0.33	5.90	717.0	372.17
Screen Undersize	1.18	0.34	9.24	1.09	0.34	7.08	185.8	96.44
Prim Rghr Conc	5.31	1.80	28.6	4.97	1.83	32.3	26.3	13.65
Prim Rghr Tail	0.62	0.10	7.70	0.45	0.09	2.93	159.5	82.80
Sec Rghr Conc	3.49	1.20	23.1	3.52	1.20	17.5	2.2	1.13
Sec Rghr Tail	0.60	0.092	7.18	0.40	0.08	2.73	157.3	81.66
Scavenger Conc	1.57	0.18	22.6	1.82	0.18	15.4	20.8	10.80
Scavenger Tail	0.18	0.055	0.77	0.21	0.06	0.80	136.5	70.87

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.35	0.63	8.3	3.38	16.5	1.82	4.9
Combined Conc	29.1	4.14	2.01	26.6	10.30	53.0	5.83	5.1
Final Tail	70.9	0.21	0.06	0.80	0.54	1.4	0.18	2.6
Unit Column Feed	375.7	0.69	0.41	6.24	1.63	13.3	1.19	8.2
Unit Column Conc	3.6	8.56	8.50	41.96	21.71	65.1	24.64	3.0
Unit Column Tail	372.2	0.61	0.33	5.90	1.44	12.8	0.97	8.9
Prim Rghr Feed	96.4	1.09	0.34	7.08	2.71	14.7	0.98	5.4
Prim Rghr Conc	13.6	4.97	1.83	32.3	12.39	66.0	5.29	5.3
Prim Rghr Tail	82.8	0.45	0.09	2.93	1.11	6.2	0.27	5.6
Sec Rghr Feed	82.8	0.45	0.09	2.93	1.11	6.2	0.27	5.6
Sec Rghr Conc	1.1	3.52	1.20	17.5	9.03	33.2	3.49	3.7
Sec Rghr Tail	81.7	0.40	0.08	2.73	1.00	5.8	0.23	5.8
Comb Rghr Feed	96.4	1.09	0.34	7.08	2.71	14.7	0.98	5.4
Comb Rghr Conc	14.8	4.86	1.78	31.1	12.13	63.4	5.15	5.2
Comb Rghr Tail	81.7	0.40	0.08	2.73	1.00	5.8	0.23	5.8
Scavenger Feed	81.7	0.40	0.08	2.73	1.00	5.8	0.23	5.8
Scavenger Conc	10.8	1.82	0.18	15.4	4.38	34.6	0.53	7.9
Scavenger Tail	70.9	0.21	0.06	0.80	0.54	1.4	0.18	2.6
Comb Mech Feed	96.4	1.09	0.34	7.08	2.71	14.7	0.98	5.4
Comb Mech Conc	25.6	3.52	1.11	24.5	8.72	51.4	3.21	5.9
Comb Mech Tail	70.9	0.21	0.06	0.80	0.54	1.4	0.18	2.6
Col + P.Rghr Feed	100.0	1.35	0.63	8.3	3.38	16.5	1.82	4.9
Col + P.Rghr Conc	17.2	5.71	3.21	34.3	14.3	65.8	9.3	4.6
Col + P.Rghr Tail	82.8	0.45	0.09	2.9	1.11	6.2	0.27	5.6

4.3. Metallurgical Balance - Distributions:

Product	Overall Wt %	Metal Distributions (%)			Mineral Distributions (%)			Gangue
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	29.1	89.2	93.1	93.2	88.7	93.9	93.1	11.5
Final Tail	70.9	10.8	6.9	6.8	11.3	6.1	6.9	88.5
Unit Column Feed	375.7	191.2	244.9	281.9	180.7	302.9	244.9	402.5
Unit Column Conc	3.6	22.5	48.1	17.9	22.8	14.1	48.1	-0.5
Unit Column Tail	372.2	168.7	196.8	263.9	157.9	288.8	196.8	403.0
Prim Rghr Feed	96.4	77.5	51.8	82.0	77.2	85.9	51.8	100.5
Prim Rghr Conc	13.6	50.2	39.6	52.9	50.0	54.7	39.6	2.8
Prim Rghr Tail	82.8	27.3	12.2	29.2	27.2	31.2	12.2	97.7
Sec Rghr Feed	82.8	27.3	12.2	29.2	27.2	31.2	12.2	97.7
Sec Rghr Conc	1.1	3.0	2.2	2.4	3.0	2.3	2.2	0.8
Sec Rghr Tail	81.7	24.4	10.1	26.8	24.2	28.9	10.1	96.9
Comb Rghr Feed	96.4	77.5	51.8	82.0	77.2	85.9	51.8	100.5
Comb Rghr Conc	14.8	53.1	41.8	55.3	53.0	57.0	41.8	3.6
Comb Rghr Tail	81.7	24.3	10.1	26.8	24.2	28.9	10.1	96.9
Scavenger Feed	81.7	24.3	10.1	26.8	24.2	28.9	10.1	96.9
Scavenger Conc	10.8	14.5	3.2	20.0	14.0	22.7	3.2	8.3
Scavenger Tail	70.9	9.8	7.0	6.8	10.2	6.2	7.0	88.5
Comb Mech Feed	96.4	77.5	51.8	82.0	77.2	85.9	51.8	100.5
Comb Mech Conc	25.6	66.7	45.0	75.2	65.9	79.9	45.0	12.0
Comb Mech Tail	70.9	10.8	6.9	6.8	11.3	6.1	6.9	88.5
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	17.2	72.7	87.8	70.8	72.8	68.8	87.8	2.3
Col + P.Rghr Tail	82.8	27.3	12.2	29.2	27.2	31.2	12.2	97.7

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
4	4,699	86.3	15.6	15.6	84.4
6	3,327	96.1	17.4	33.0	67.0
8	2,362	57.2	10.4	43.4	56.6
10	1,651	53.0	9.6	53.0	47.0
14	1,168	33.2	6.0	59.0	41.0
20	833	25.1	4.5	63.5	36.5
28	589	22.5	4.1	67.6	32.4
35	417	20.5	3.7	71.3	28.7
48	295	17.9	3.2	74.6	25.4
65	208	17.8	3.2	77.8	22.2
100	147	17.6	3.2	81.0	19.0
150	104	15.6	2.8	83.8	16.2
200	74	15.0	2.7	86.5	13.5
270	53	14.3	2.6	89.1	10.9
400	37	10.2	1.8	91.0	9.0
Pan	-37	49.9	9.0	100.0	-
Total	-	**552.2**	**100.0**	-	-
K80	**4,401**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	0.7	0.2	0.2	99.8
14	1,168	3.4	1.0	1.2	98.8
20	833	12.9	3.9	5.2	94.8
28	589	31.3	9.5	14.7	85.3
35	417	41.9	12.8	27.5	72.5
48	295	36.5	11.1	38.6	61.4
65	208	30.1	9.2	47.7	52.3
100	147	29.8	9.1	56.8	43.2
150	104	24.4	7.4	64.3	35.7
200	74	21.1	6.4	70.7	29.3
270	53	20.3	6.2	76.9	23.1
400	37	15.2	4.6	81.5	18.5
Pan	-37	60.8	18.5	100.0	-
Total	-	**328.4**	**100.0**	-	-
K80	**516**				

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	29.1	89.2	93.1	93.2	88.7	93.9	93.1	11.5
Final Tail	70.9	10.8	6.9	6.8	11.3	6.1	6.9	88.5
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	0.9	11.8	19.6	6.4	12.6	4.7	19.6	-0.1
Unit Column Tail	99.1	88.2	80.4	93.6	87.4	95.3	80.4	100.1
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	14.1	64.8	76.4	64.5	64.7	63.7	76.4	2.8
Prim Rghr Tail	85.9	35.2	23.6	35.5	35.3	36.3	23.6	97.2
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	1.4	10.8	17.7	8.2	11.1	7.3	17.7	0.8
Sec Rghr Tail	98.6	89.2	82.3	91.8	88.9	92.7	82.3	99.2
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	15.3	68.6	80.6	67.4	68.7	66.4	80.6	3.6
Comb Rghr Tail	84.7	31.4	19.4	32.6	31.3	33.6	19.4	96.4
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	13.2	59.5	31.2	74.5	57.8	78.5	31.2	8.6
Scavenger Tail	86.8	40.5	68.8	25.5	42.2	21.5	68.8	91.4
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	26.5	86.1	86.7	91.7	85.4	93.0	86.7	11.9
Comb Mech Tail	73.5	13.9	13.3	8.3	14.6	7.0	13.3	88.1
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	17.2	72.7	87.8	70.8	72.8	68.8	87.8	2.3
Col + P.Rghr Tail	82.8	27.3	12.2	29.2	27.2	31.2	12.2	97.7

5. Screen Analyses:

Detailed in the following pages.

Column Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.8	1.2	1.2	98.8
14	1,168	14.4	3.6	4.8	95.2
20	833	31.4	7.9	12.8	87.2
28	589	58.1	14.7	27.4	72.6
35	417	73.7	18.6	46.0	54.0
48	295	66.1	16.7	62.7	37.3
65	208	40.3	10.2	72.9	27.1
100	147	22.1	5.6	78.5	21.5
150	104	14.5	3.7	82.1	17.9
200	74	11.7	3.0	85.1	14.9
270	53	10.7	2.7	87.8	12.2
400	37	8.4	2.1	89.9	10.1
Pan	-37	40.1	10.1	100.0	-
Total	-	**396.3**	**100.0**	-	-
K80	**705**				

Column Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	12.1	6.1	6.1	93.9
100	147	12.8	6.5	12.6	87.4
150	104	16.5	8.3	20.9	79.1
200	74	20.4	10.3	31.2	68.8
270	53	22.0	11.1	42.4	57.6
400	37	22.5	11.4	53.7	46.3
Pan	-37	91.5	46.3	100.0	-
Total	-	**197.8**	**100.0**	-	-
K80	**109**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.3	1.1	1.1	98.9
14	1,168	7.1	3.5	4.7	95.3
20	833	17.9	8.9	13.6	86.4
28	589	35.8	17.8	31.4	68.6
35	417	48.8	24.3	55.6	44.4
48	295	47.4	23.6	79.2	20.8
65	208	24.7	12.3	91.5	8.5
100	147	8.0	4.0	95.5	4.5
150	104	3.3	1.6	97.1	2.9
200	74	1.6	0.8	97.9	2.1
270	53	0.9	0.4	98.4	1.6
400	37	0.5	0.2	98.6	1.4
Pan	-37	2.8	1.4	100.0	-
Total	-	**201.1**	**100.0**	-	-
K80	**734**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	2.3	1.1	1.1	98.9
14	1,168	8.1	4.0	5.1	94.9
20	833	19.1	9.4	14.5	85.5
28	589	35.5	17.4	31.9	68.1
35	417	46.6	22.9	54.8	45.2
48	295	44.9	22.1	76.9	23.1
65	208	32.3	15.9	92.8	7.2
100	147	9.0	4.4	97.2	2.8
150	104	4.4	2.2	99.4	0.6
200	74	2.6	1.3	100.6	-0.6
270	53	1.7	0.8	101.5	-1.5
400	37	1.3	0.6	102.1	-2.1
Pan	-37	-4.3	-2.1	100.0	-
Total	-	**203.5**	**100.0**	-	-
K80	**745**				

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	8.4	5.7	5.7	94.3
100	147	16.7	11.3	17.0	83.0
150	104	14.3	9.7	26.7	73.3
200	74	14.6	9.9	36.6	63.4
270	53	15.8	10.7	47.3	52.7
400	37	14.6	9.9	57.2	42.8
Pan	-37	63.2	42.8	100.0	-
Total	-	**147.6**	**100.0**	-	-
K80	**132**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.7	3.6	3.6	96.4
100	147	1.7	2.3	5.8	94.2
150	104	1.6	2.1	7.9	92.1
200	74	3.4	4.5	12.5	87.5
270	53	5.7	7.5	20.0	80.0
400	37	5.6	7.4	27.4	72.6
Pan	-37	54.8	72.6	100.0	-
Total	-	**75.5**	**100.0**	-	-
K80	**53**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	24.4	11.6	11.6	88.4
100	147	32.6	15.5	27.1	72.9
150	104	27.2	12.9	40.0	60.0
200	74	23.8	11.3	51.3	48.7
270	53	20.2	9.6	60.9	39.1
400	37	14.8	7.0	68.0	32.0
Pan	-37	67.4	32.0	100.0	-
Total	-	**210.4**	**100.0**	-	-
K80	**174**				

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	3.6	1.3	1.3	98.7
14	1,168	11.8	4.2	5.5	94.5
20	833	23.6	8.4	13.8	86.2
28	589	43.0	15.3	29.1	70.9
35	417	54.8	19.4	48.5	51.5
48	295	52.1	18.5	67.0	33.0
65	208	33.1	11.7	78.8	21.2
100	147	16.8	6.0	84.7	15.3
150	104	9.6	3.4	88.1	11.9
200	74	6.5	2.3	90.5	9.5
270	53	5.0	1.8	92.2	7.8
400	37	3.7	1.3	93.5	6.5
Pan	-37	18.2	6.5	100.0	-
Total	-	**281.8**	**100.0**	-	-
K80	**724**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	13.4	8.7	8.7	91.3
100	147	18.7	12.1	20.7	79.3
150	104	16.8	10.9	31.6	68.4
200	74	16.4	10.6	42.2	57.8
270	53	15.7	10.1	52.3	47.7
400	37	12.4	8.0	60.3	39.7
Pan	-37	61.4	39.7	100.0	-
Total	-	**154.8**	**100.0**	-	-
K80	**150**				

Test No. PP-41

1. **Purpose:** To duplicate the conditions of test PP-36 in three tests per day operation.

2. **Procedure:** All process units started, including unit column.

2.1. **Flowsheet:** The flowsheet is shown in Figure 1b.

2.2. **Equipment:** The equipment list is shown in Table 1b.

3. **Results:**

Flotation Feed Size		82.0 % -100 mesh				
Grades / Recoveries		Ni	Cu	Pn	Cp	Pn/Po
Head Grades		1.43	0.60	3.57	1.75	5.23
Unit Column	Grade	6.56	4.46	16.6	12.9	3.67
	Recov	36.1	58.5	36.8	58.5	0.99
Primary Rougher	Grade	5.31	1.88	13.42	5.44	4.43
	Recov	33.6	28.3	34.2	28.3	2.59
Secondary Rougher	Grade	3.69	1.27	9.31	3.69	4.63
	Recov	1.9	1.6	1.9	1.6	0.43
Scavenger	Grade	1.61	0.16	3.70	0.46	11.1
	Recov	19.0	4.5	17.5	4.5	12.16
Overall Circuit	Grade	3.74	1.61	9.27	4.68	5.46
	Recov	90.3	92.9	90.0	92.9	16.17

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data

(based on 60 mesh Kason screen with 234 µm aperture)

C L R
1318%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	38.6	76.9	79.2	0.0
-48+100	18.2	20.3	16.3	20.7
-100+200	13.9	3.4	2.4	21.4
-200+400	10.8	1.5	0.7	18.2
-400	18.5	-2.1	1.4	39.7

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	1670 %	74.7	1248 %
-48+100	62 %	19.0	12 %
-100+200	757 %	4.7	35 %
-200+400	944 %	2.4	22 %
-400	-603 %	-0.8	5 %
Total		100.0	**1318 %**

3.1.3. Overall Mill Report:

Net Power Usage:	4.63 kWh/t
K80 Feed:	4,681 microns
K80 Product:	138 microns
Work Index (metric):	6.6
Screen Undersize:	82.0 %-100 mesh

3.1.4. Overall Screen Report:

Product	K80 (μm)	%-100 m
Rod Mill Feed	4,681	18.5
Rod Mill Discharge	759	38.2
Ball Mill Feed	934	4.6
Ball Mill Discharge	793	12.9
Column Feed	753	24.8
Column Conc	79	95.6
Screen Feed	818	18.8
Screen Undersize	138	82.0
Prim Rghr Conc	123	84.8
Sec Rghr Conc	59	91.5
Scavenger Tail	174	72.9

3.2. Reagent Additions:

Average Feed Rate: 0.199 t/h

Addition Point	Reagent	Strength	Rate (mL/min)	Dosage (g/t)
Column Feed	NaIX	2.0%	3.1	18.7
	DF-250	2.0%	4.8	28.9
Rougher Feed	NaIX	2.0%	5.1	30.8
	DF-250	2.0%	2.8	16.9
Scavenger 1 Feed	NaIX	2.0%	7.1	42.8
	DF-250	2.0%	2.0	12.1
	CuSO4	2.0%	6.0	36.2
Scavenger 2 Feed	NaIX	2.0%	5.0	30.2
	DF-250	2.0%	4.3	25.9
Total	**NaIX**		20.3	**122.4**
	DF-250		13.9	**83.8**
	CuSO4		6.0	**36.2**

3.1. Grinding Circuit Operations:

3.1.1. Rod Mill Report:

Feed:	201.7 kg/h of -1/4 inch feed. (Wet Sple 733.1 g)
	(Dry Sple 723.2 g)
Feed Rate:	199.0 kg/h of dry ore. (Moisture 1.35 %)
Mill Speed:	45 RPM (85% of critical speed)
Rod Charge:	160 kg
Rod Mill Feed:	Total 892 kg in 4.42 hr
	Sample 403 kg in 2.00 hr
Rod Mill Discharge:	1,737 g/L (61 % Sol at Solid SG of 3.34)
	47.1 % plus 48 mesh
	38.2 % minus 100 mesh
Input Power:	33.10 for 3 disc revolutions
	1.17 kW (95% drive efficiency)
Average Power:	1.12 kW Gross
	0.47 kW No Load
	0.64 kW Net
Net Power Usage:	3.22 kWh/tonne of -1/4 inch feed.
K80 Feed:	4,681 microns
K80 Product:	759 microns
Work Index (metric):	14.9

3.1.2. Ball Mill Report:

Feed:	Screen Oversize (at 298 % circ. load)
Feed Rate:	593.4 kg/h
Mill Speed:	41 RPM (77% of critical speed)
Ball Charge:	100 kg
Screen Undersize:	1,173 g/L (21 % Sol at S 3.34)
Ball Mill Discharge:	1,950 g/L (70 % Sol at S 3.34)
	70.8 % plus 48 mesh
	12.9 % minus 100 mesh
Input Power:	27.26 for 3 disc revolutions
	1.43 kW (95% drive efficiency)
Average Power:	1.35 kW Gross
	0.52 kW No Load
	0.83 kW Net
Net Power Usage:	1.40 kWh/tonne of screen oversize.
K80 Feed:	759 microns
K80 Product:	138 microns
Work Index (metric):	2.9

4. Metallurgical Results:

4.1. Direct and Adjusted Assays: (BILCO Mass Balance)

Circulating Load Ratio **From screens 225%** **From BILCO 298%**

Product	Direct Assays % Ni	Direct Assays % Cu	Direct Assays % S(T)	Adjusted Assays % Ni	Adjusted Assays % Cu	Adjusted Assays % S(T)	Mass Flow kg/h	Mass % BILCO
Rod Mill Feed	1.32	0.60	9.30	1.43	0.60	9.25	199.0	100.00
Rod Mill Discharge	1.41	0.65	10.3	1.43	0.60	9.25	199.0	100.00
Ball Mill Feed	0.49	0.36	6.25	0.44	0.34	5.87	593.4	298.20
Ball Mill Discharge	0.43	0.33	5.61	0.44	0.34	5.87	593.4	298.20
Unit Column Feed	0.74	0.45	6.93	0.69	0.41	6.71	792.4	398.20
Unit Column Conc	7.04	4.2	33.5	6.56	4.46	34.42	15.7	7.90
Screen Feed	0.51	0.30	5.83	0.58	0.33	6.14	776.6	390.30
Screen Undersize	0.97	0.32	7.6	1.00	0.27	7.09	183.3	92.10
Prim Rghr Conc	6.02	1.72	28.9	5.31	1.88	30.08	18.1	9.09
Prim Rghr Tail	0.58	0.09	5.83	0.53	0.10	4.57	165.2	83.01
Sec Rghr Conc	3.69	1.28	21.2	3.69	1.27	21.57	1.5	0.74
Sec Rghr Tail	0.52	0.087	3.47	0.50	0.08	4.42	163.7	82.26
Scavenger Conc	1.58	0.160	19.7	1.61	0.16	17.80	33.7	16.92
Scavenger Tail	0.21	0.066	0.97	0.21	0.07	0.95	130.0	65.34

3.3. Pulp Density and pH:

Measurement Point	Density (g/L)	pH	Temp (deg C)	Specific Gravity
Rod Mill Discharge	1,737			3.33
Ball Mill Discharge	1,950			
Screen Feed	1,717	10.40		
Screen Undersize	1,173	10.00	24.0	
Scavenger 1 Feed	1,177	9.50		
Scavenger 2 Tail	1,197			

3.4. Estimated Residence Time:

Flotation Stage	Volume L	Feed kg/h	Density g/L	Rate L/min	Time min
Unit Column	41	792	1.72	12.9	3.2
Primary Rougher	56	183	1.72	3.0	18.8
Secondary Rougher	28	165	1.18	10.9	2.6
Scavenger	336	164	1.20	9.7	34.7
Total	420				56.0

4.3. Metallurgical Balance - Distributions:

Product	Overall	Metal Distributions (%)			Mineral Distributions (%)			Gangue
	Wt %	Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	34.7	90.3	92.9	93.3	90.0	93.8	92.9	16.2
Final Tail	65.3	9.7	7.1	6.7	10.0	6.2	7.1	83.8
Unit Column Feed	398.2	192.2	268.6	288.8	180.3	307.7	268.6	433.7
Unit Column Conc	7.9	36.1	58.5	29.4	36.8	25.8	58.5	1.0
Unit Column Tail	390.3	156.0	210.1	259.4	143.6	282.0	210.1	432.7
Prim Rghr Feed	92.1	63.9	41.6	70.6	63.3	74.2	41.6	99.0
Prim Rghr Conc	9.1	33.6	28.3	29.6	34.2	29.0	28.3	2.6
Prim Rghr Tail	83.0	30.3	13.3	41.0	29.1	45.3	13.3	96.4
Sec Rghr Feed	83.0	30.6	13.1	41.0	29.5	45.2	13.1	96.4
Sec Rghr Conc	0.7	1.9	1.6	1.7	1.9	1.7	1.6	0.4
Sec Rghr Tail	82.3	28.6	11.5	39.3	27.5	43.5	11.5	96.0
Comb Rghr Feed	92.1	63.9	41.6	70.6	63.3	74.2	41.6	99.0
Comb Rghr Conc	9.8	35.6	29.9	31.3	36.1	30.7	29.9	3.0
Comb Rghr Tail	82.3	28.3	11.7	39.3	27.2	43.5	11.7	96.0
Scavenger Feed	82.3	28.6	11.5	39.3	27.5	43.5	11.5	96.0
Scavenger Conc	16.9	19.0	4.5	32.6	17.5	37.3	4.5	12.2
Scavenger Tail	65.3	9.6	7.0	6.7	10.0	6.2	7.0	83.8
Comb Mech Feed	92.1	63.9	41.6	70.6	63.3	74.2	41.6	99.0
Comb Mech Conc	26.8	54.2	34.6	63.9	53.3	68.0	34.6	15.2
Comb Mech Tail	65.3	9.7	7.1	6.7	10.0	6.2	7.1	83.8
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	17.0	69.4	86.9	59.0	70.5	54.8	86.9	3.6
Col + P.Rghr Tail	83.0	30.6	13.1	41.0	29.5	45.2	13.1	96.4

4.2. Metallurgical Balance - Assays:

Mineral Calculations (per Falconbridge - Strathcona)

Pentlandite	% Pn = (2.80 x %Ni) - (0.045 x %S) - (0.045 x %Cu)
Pyrrhotite	% Po = (2.55 x %S) - (2.58 x %Cu) - (2.33 x %Ni)
Chalcopyrite	% Cp = (2.90 x %Cu)
Gangue	% Ga = 100 - Pn - Po - Cp

Product	Overall Wt %	Metal Assays			Mineral Assays			Ratio
		% Ni	% Cu	% S(T)	% Pn	% Po	% Cp	Po / Pn
O'All Circuit Feed	100.0	1.43	0.60	9.2	3.57	18.7	1.75	5.2
Combined Conc	34.7	3.74	1.61	24.9	9.27	50.6	4.68	5.5
Final Tail	65.3	0.21	0.07	0.95	0.55	1.8	0.19	3.2
Unit Column Feed	398.2	0.69	0.41	6.71	1.62	14.4	1.18	8.9
Unit Column Conc	7.9	6.56	4.46	34.42	16.62	61.0	12.93	3.7
Unit Column Tail	390.3	0.58	0.33	6.14	1.32	13.5	0.94	10.2
Prim Rghr Feed	92.1	1.00	0.27	7.09	2.45	15.1	0.79	6.1
Prim Rghr Conc	9.1	5.31	1.88	30.1	13.42	59.5	5.44	4.4
Prim Rghr Tail	83.0	0.53	0.10	4.57	1.27	10.2	0.28	8.0
Sec Rghr Feed	83.0	0.53	0.10	4.57	1.27	10.2	0.28	8.0
Sec Rghr Conc	0.7	3.69	1.27	21.6	9.31	43.1	3.69	4.6
Sec Rghr Tail	82.3	0.50	0.08	4.42	1.19	9.9	0.24	8.3
Comb Rghr Feed	92.1	1.00	0.27	7.09	2.45	15.1	0.79	6.1
Comb Rghr Conc	9.8	5.18	1.83	29.4	13.11	58.3	5.31	4.4
Comb Rghr Tail	82.3	0.50	0.08	4.42	1.19	9.9	0.24	8.3
Scavenger Feed	82.3	0.50	0.08	4.42	1.19	9.9	0.24	8.3
Scavenger Conc	16.9	1.61	0.16	17.8	3.70	41.2	0.46	11.1
Scavenger Tail	65.3	0.21	0.07	0.95	0.55	1.8	0.19	3.2
Comb Mech Feed	92.1	1.00	0.27	7.09	2.45	15.1	0.79	6.1
Comb Mech Conc	26.8	2.91	0.78	22.1	7.11	47.5	2.25	6.7
Comb Mech Tail	65.3	0.21	0.07	0.95	0.55	1.8	0.19	3.2
Col + P.Rghr Feed	100.0	1.43	0.60	9.2	3.57	18.7	1.75	5.2
Col + P.Rghr Conc	17.0	5.86	3.08	32.1	14.8	60.3	8.9	4.1
Col + P.Rghr Tail	83.0	0.53	0.10	4.6	1.27	10.2	0.28	8.0

Rod Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	μm	grams	Individual	Cumulative	Cumulative
4	4,699	118.6	19.6	19.6	80.4
6	3,327	104.9	17.3	36.9	63.1
8	2,362	60.3	10.0	46.8	53.2
10	1,651	56.4	9.3	56.1	43.9
14	1,168	32.8	5.4	61.6	38.4
20	833	24.3	4.0	65.6	34.4
28	589	22.6	3.7	69.3	30.7
35	417	20.9	3.4	72.8	27.2
48	295	17.5	2.9	75.6	24.4
65	208	17.7	2.9	78.6	21.4
100	147	17.9	3.0	81.5	18.5
150	104	15.3	2.5	84.0	16.0
200	74	15.4	2.5	86.6	13.4
270	53	14.4	2.4	89.0	11.0
400	37	11.0	1.8	90.8	9.2
Pan	-37	55.9	9.2	100.0	-
Total	-	**605.9**	**100.0**	-	-
K80	**4,681**				

Rod Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	μm	grams	Individual	Cumulative	Cumulative
10	1,651	8.6	2.4	2.4	97.6
14	1,168	19.9	5.5	7.8	92.2
20	833	32.3	8.9	16.7	83.3
28	589	41.5	11.4	28.1	71.9
35	417	39.4	10.8	38.9	61.1
48	295	29.9	8.2	47.1	52.9
65	208	28.1	7.7	54.9	45.1
100	147	25.3	7.0	61.8	38.2
150	104	21.5	5.9	67.7	32.3
200	74	19.7	5.4	73.1	26.9
270	53	16.6	4.6	77.7	22.3
400	37	13.5	3.7	81.4	18.6
Pan	-37	67.7	18.6	100.0	-
Total	-	**364.0**	**100.0**	-	-
K80	**759**				

4.4. Individual Unit Performance - Distributions:

Product	Individual Wt %	Metal Distributions			Mineral Distributions			
		Ni	Cu	S(T)	Pn	Po	Cp	Ga
O'All Circuit Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Combined Conc	34.7	90.3	92.9	93.3	90.0	93.8	92.9	16.2
Final Tail	65.3	9.7	7.1	6.7	10.0	6.2	7.1	83.8
Unit Column Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Unit Column Conc	2.0	18.8	21.8	10.2	20.4	8.4	21.8	0.2
Unit Column Tail	98.0	81.2	78.2	89.8	79.6	91.6	78.2	99.8
Prim Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Prim Rghr Conc	9.9	52.6	68.1	41.9	54.0	39.0	68.1	2.6
Prim Rghr Tail	90.1	47.4	31.9	58.1	46.0	61.0	31.9	97.4
Sec Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sec Rghr Conc	0.9	6.3	12.0	4.2	6.6	3.8	12.0	0.4
Sec Rghr Tail	99.1	93.7	88.0	95.8	93.4	96.2	88.0	99.6
Comb Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Rghr Conc	10.7	55.6	71.8	44.3	57.0	41.3	71.8	3.0
Comb Rghr Tail	89.3	44.4	28.2	55.7	43.0	58.7	28.2	97.0
Scavenger Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scavenger Conc	20.6	66.3	38.9	82.9	63.6	85.8	38.9	12.7
Scavenger Tail	79.4	33.7	61.1	17.1	36.4	14.2	61.1	87.3
Comb Mech Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Comb Mech Conc	29.1	84.9	83.0	90.5	84.2	91.7	83.0	15.3
Comb Mech Tail	70.9	15.1	17.0	9.5	15.8	8.3	17.0	84.7
Col + P.Rghr Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Col + P.Rghr Conc	17.0	69.4	86.9	59.0	70.5	54.8	86.9	3.6
Col + P.Rghr Tail	83.0	30.6	13.1	41.0	29.5	45.2	13.1	96.4

5. Screen Analyses:

Detailed in the following pages.

Column Feed

Size Mesh (Tyler)	 µm	Weight grams	% Retained Individual	 Cumulative	% Passing Cumulative
10	1,651	6.1	2.4	2.4	97.6
14	1,168	12.4	4.8	7.2	92.8
20	833	22.8	8.8	16.0	84.0
28	589	35.1	13.6	29.6	70.4
35	417	39.9	15.5	45.1	54.9
48	295	35.6	13.8	58.9	41.1
65	208	26.1	10.1	69.0	31.0
100	147	15.9	6.2	75.2	24.8
150	104	10.5	4.1	79.3	20.7
200	74	8.6	3.3	82.6	17.4
270	53	7.9	3.1	85.7	14.3
400	37	6.2	2.4	88.1	11.9
Pan	-37	30.7	11.9	100.0	-
Total	-	**257.8**	**100.0**	-	-
K80	**753**				

Column Concentrate

Size Mesh (Tyler)	 µm	Weight grams	% Retained Individual	 Cumulative	% Passing Cumulative
65	208	2.5	1.2	1.2	98.8
100	147	6.3	3.1	4.4	95.6
150	104	13.3	6.6	10.9	89.1
200	74	20.4	10.1	21.0	79.0
270	53	30.1	14.9	35.9	64.1
400	37	29.0	14.3	50.2	49.8
Pan	-37	100.6	49.8	100.0	-
Total	-	**202.2**	**100.0**	-	-
K80	**79**				

Ball Mill Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	11.8	3.1	3.1	96.9
14	1,168	29.3	7.7	10.9	89.1
20	833	51.5	13.6	24.5	75.5
28	589	70.9	18.7	43.2	56.8
35	417	77.4	20.4	63.6	36.4
48	295	70.0	18.5	82.1	17.9
65	208	37.4	9.9	92.0	8.0
100	147	12.8	3.4	95.4	4.6
150	104	4.9	1.3	96.6	3.4
200	74	2.3	0.6	97.3	2.7
270	53	1.3	0.3	97.6	2.4
400	37	0.7	0.2	97.8	2.2
Pan	-37	8.4	2.2	100.0	-
Total	-	**378.7**	**100.0**	-	-
K80	**934**				

Ball Mill Discharge

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	4.1	1.8	1.8	98.2
14	1,168	12.2	5.3	7.1	92.9
20	833	24.3	10.6	17.8	82.2
28	589	38.2	16.7	34.5	65.5
35	417	43.8	19.2	53.6	46.4
48	295	39.4	17.2	70.8	29.2
65	208	25.2	11.0	81.9	18.1
100	147	12.0	5.2	87.1	12.9
150	104	6.4	2.8	89.9	10.1
200	74	4.5	2.0	91.9	8.1
270	53	3.5	1.5	93.4	6.6
400	37	2.4	1.0	94.4	5.6
Pan	-37	12.7	5.6	100.0	-
Total	-	**228.7**	**100.0**	-	-
K80	**793**				

Test No. PP-41

Primary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	10.9	4.6	4.6	95.4
100	147	25.2	10.6	15.2	84.8
150	104	22.7	9.5	24.7	75.3
200	74	26.1	11.0	35.7	64.3
270	53	32.3	13.6	49.3	50.7
400	37	27.7	11.7	61.0	39.0
Pan	-37	92.8	39.0	100.0	-
Total	-	**237.7**	**100.0**	-	-
K80	**123**				

Secondary Rougher Concentrate

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	1.6	5.2	5.2	94.8
100	147	1.0	3.3	8.5	91.5
150	104	0.7	2.3	10.8	89.2
200	74	1.5	4.9	15.7	84.3
270	53	2.0	6.5	22.2	77.8
400	37	2.1	6.9	29.1	70.9
Pan	-37	21.7	70.9	100.0	-
Total	-	**30.6**	**100.0**	-	-
K80	**59**				

Scavenger Tailing

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	21.7	11.2	11.2	88.8
100	147	30.6	15.8	27.1	72.9
150	104	24.5	12.7	39.7	60.3
200	74	20.9	10.8	50.5	49.5
270	53	18.5	9.6	60.1	39.9
400	37	13.6	7.0	67.1	32.9
Pan	-37	63.5	32.9	100.0	-
Total	-	**193.3**	**100.0**	-	-
K80	**174**				

Test No. PP-41

Screen Feed

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
10	1,651	7.1	2.0	2.0	98.0
14	1,168	21.1	6.0	8.0	92.0
20	833	39.5	11.3	19.3	80.7
28	589	55.1	15.7	35.0	65.0
35	417	59.6	17.0	52.0	48.0
48	295	51.7	14.7	66.8	33.2
65	208	32.1	9.2	75.9	24.1
100	147	18.5	5.3	81.2	18.8
150	104	11.1	3.2	84.3	15.7
200	74	8.7	2.5	86.8	13.2
270	53	7.8	2.2	89.1	10.9
400	37	6.1	1.7	90.8	9.2
Pan	-37	32.3	9.2	100.0	-
Total	-	**350.7**	**100.0**	-	-
K80	**818**				

Screen Undersize

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	11.7	6.7	6.7	93.3
100	147	19.9	11.4	18.0	82.0
150	104	18.9	10.8	28.8	71.2
200	74	18.4	10.5	39.3	60.7
270	53	18.7	10.7	50.0	50.0
400	37	14.5	8.3	58.3	41.7
Pan	-37	73.0	41.7	100.0	-
Total	-	**175.1**	**100.0**	-	-
K80	**138**				

Calculation of Circulating Load Ratio (CLR)
Using Grouped Screen Analysis Data

(based on 60 mesh Kason screen with 234 µm aperture)

C L R
335%

Size (mesh)	Individual and Cumulative % on Fraction			
	RMD	BMD	SOS	SUS
+48	47.1	70.8	82.1	0.0
-48+100	14.7	16.3	13.3	18.0
-100+200	11.3	4.8	1.9	21.3
-200+400	8.3	2.6	0.5	19.0
-400	18.6	5.6	2.2	41.7

Size (mesh)	Fractional CLR	Calc SFD	Prop'n CLR
+48	419 %	66.3	277 %
-48+100	112 %	15.5	17 %
-100+200	348 %	6.2	22 %
-200+400	521 %	3.5	18 %
-400	692 %	8.5	59 %
Total		100.0	**335 %**